

# LIGHTING THE FIRE

Astronomy Camps at  
The University of Arizona  
have had a life-changing  
impact on students.

by Don McCarthy



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Courtesy Astronomical Society of the Pacific

Einstein's Amazing Universe

Students using the 10-meter  
submillimeter radio telescope  
for a Camp project. Image  
courtesy Jeff Register.

Growing up in the 1950s and 60s, I was captivated by the adventure, both physical and mental, of the era of space exploration. I longed to be part of that process and somehow to contribute personally. So I became a scientist with the goal of working in space.

However, I missed the final cut of the original Shuttle astronaut selection in 1977, as 10,000 applicants were whittled down to 100 and finally to only a few.

From that exciting experience I learned something surprising: NASA had not understood the ‘deep impact’ that Mercury, Gemini, and Apollo had on a new generation. The combination of forefront research and education is a powerful force to inspire and empower people of all ages. Yet, the benefits of inspiration and education are long-term. They do not lend themselves easily to quantitative assessment and may only be realized decades later.

For nearly three decades I have led a group of dedicated students and educators in an inspiring educational program called “Astronomy Camp.” Sponsored by The University of Arizona (UA) Alumni Association, the “Camps” have engaged students from around the world and impacted my university and the nation in surprising ways. After five years of operation we described our approach and its impact in *Mercury* (Nov./Dec. 1993). Now, on our 25th anniversary, we will soon enroll children of former Campers! Our experience illustrates the benefits of teaching science authentically, merged holistically with its partners of math, engineering, and technology. It also contains lessons to benefit parents, educators, and administrators who

## Guiding Principles

**O**ur efforts are guided by three basic principles. The first one resonated with me while listening to a post-flight press conference conducted by the Apollo 15 crew. Commander David Scott quoted Plutarch: “The mind is not a vessel to be filled but a fire to be lighted.” A single moment can influence an entire life. So every day at Camp includes inspirational moments with guest speakers, unusual activities, watching satellites, looking for the green flash, and listening to President Kennedy’s famous “Why go to the Moon?” speech. Also, every night we dark adapt under the stars to a variety of musical selections.

I learned a second principle from veteran high school science teacher Jeff Lockwood who shared the article “Never Playing the Game” by Robert Yager. Yager stated: “In typical science teaching, we ignore the lessons we might learn from sports.” In sports we put people on the field quickly instead of confining them to a classroom watching videos of other people hitting home runs. Typical science teaching forces students to memorize laws discovered by others. At Camp, we quickly put students in charge of our telescopes, instruments, and activities, coaching them as needed to succeed in their observations and experiments. As a result, participants experience realistic science. As one of our Girl Scout leaders commented: “I always thought that science was just memorizing



Students controlling the 10-meter submillimeter radio telescope on Mt. Graham.

facts, but you guys are encouraging us to think and explore.”

The third principle is adapted from a corporate slogan: We measure success one ‘student’ at a time (Dean Witter Reynolds, Inc.). Typically, our student-faculty ratio is about two or three to one. We emphasize personal interaction and mentoring. Seeing Campers as capable, responsible, contributing scientists permeates every activity — including cooking and cleaning together as faculty/staff/students. Such teamwork overcomes generational barriers and builds long-lasting bonds.

seek to solve the growing problem of a changed society that seems not to value basic research and numeracy.

## A New Direction

Joan Morrill and astronomer Ray White conceived Astronomy Camp as an outreach for children of UA alumni. Ray quickly realized that he really didn't have much patience for teenagers, and I soon found myself leading the program. When it began in 1988, "science" was entirely the realm of professionals, and astronomical observatories were off-limits to the public at night. Although scientists were dissuaded from spending time in science education, we pioneered the idea of enabling the public to "become scientists."

Using the "Sky Island" environment of our observatories in the Catalina mountains (9,200 feet) north of Tucson, we began bringing teenagers, adults, educators, college students, Girl Scout leaders, and school groups to live and work at these observatories, primarily during weekends, holidays, and vacation months. Our guests learned to operate research-class telescopes and technology, interact with leading scientists, interpret their own observations, investigate their own questions and curiosities, and most importantly have fun exploring together. Today our Camps also utilize most of the facilities at Kitt Peak National Observatory, and the potential exists to extend the model.

The Advanced Teen Camp attracts some of the nation's best students, in part because they can engage in publishable research projects using major astronomical facilities under dark skies in southwest Arizona. Such facilities include the Arizona Radio Observatory, the Large Binocular Telescope, the University Mirror Lab, the McMath-Pierce Solar Telescope, and the WIYN and RCT telescopes on Kitt Peak. In 2001, under the direction of former Camper John Moustakas, 29 advanced teen Campers contributed to professional research by being the first group to classify the spectra of three new supernovae using the 2.3-meter Bok telescope. All their names were listed on the three international discovery telegrams. Our students often continue their projects and place highly in local, regional, and national science fairs.

## The Astronomy Camp Model

Astronomy Camps promote an authentic understanding of science, research, and engineering among young students and adults by providing unique, hands-on, "immersion" adventures in scientific



Astronomy Camp

**Student observing Fraunhofer absorption lines in the Sun's spectrum using the Camp's spectrometer on the 60-inch telescope on Mt. Lemmon.**

exploration via astronomy and related subjects at high-altitude observatories. We model the entire scientific process — from the inception of an idea, hypothesizing, and proposing to a Telescope Allocation Committee, to observing, interpreting, presenting, and publishing results. Students work in teams, just like real scientists.

Besides focusing on astronomy, we show how science, math, and technology impact daily life, and how experience in these subjects can empower students in any career they choose. We begin each day with a problem in critical thinking. Throughout the day we incorporate a holistic approach to STEM education via our language and by a diversity of activities such as eTextiles, a liquid-nitrogen cannon, electrocution of pickles, dissection of cow's eyes, music (see the Whitehouse article on [page 22](#)), space art, hiking the solar system and nearby stars (to scale), and observing natural phenomena. Every aspect, including cooking and cleaning, is designed to reinforce scientific principles and quantitative literacy. We want students to value these subjects and to experience their interrelationships as imagined by an Honor's middle school student who said:

*Astronomy Camp will be a fun and interesting way to introduce myself to science the way it is actually done.... I have always heard a lot about science and math being related, but I have never actually used them together. I have finished an entire year of algebra, but never has there been any science in it. The same holds true in my science class. Frankly, I have never seen any connection between the two of them.*

In so doing we hope to alleviate the problems faced in college where even our Honor's students see "...no value in taking math except to pass a test in math class." Is it any wonder they do not



Astronomy Camp

**Students programming LEDs on their eTextiles shirts.**



Astronomy Camp

**It's not entirely serious at Astronomy Camp, as evidenced by this toilet plunger "activity" on opening night.**

understand simple fractions, ratios, percentages, or how to read a graph? Kate Follette and I discussed this situation more thoroughly in another *Mercury* article (Winter 2012, page 20).

The Camps do not fit today's standard mold for education programs. We have never received external funding, we work with small numbers (about 30 per Camp), we do not have a large marketing budget, we welcome risk and change, we immerse participants in the process of science, we live and work around the clock at high-altitude observatories, we adopt a personal approach, we create most of our own activities, and we pay modest salaries.

The Camps are financially self-sufficient. We once sought NSF funding but were told "You can't teach students anything in one week." This shortsighted attitude fails to recognize our first principle — the value of inspiration. Our operation depends entirely on student tuition, donations, volunteer work, and cleverness. Thus, we can focus our energy on the Campers. We enjoy the freedom to design our own activities, determine our own schedule, react spontaneously to students' interests and to unexpected phenomena in the sky, and to recruit and follow-up with students without the burden of paperwork and proposals.

## A Life-changing Experience

The impact of Astronomy Camp has surprised parents who wonder why their child had a "life-changing experience." For example, it is not unusual for Camp students to improve their attitudes to school, change schools to have a stronger math-science emphasis, form Facebook groups, and arrange reunions.

Campers have also entered and won major science fair competitions, published articles about Camp, donated funds, returned as staff members, enrolled in the UA, and even met their eventual life-partner at Camp. Seven have become research astronomers and 22 PhDs (10 in astronomy) are in progress. Many others earned advanced degrees in a wide variety of scientific and technical fields as well as in business, creative writing, dance, economics, education, engineering, library science, organ and composition, and more.

In hindsight, we might have predicted the life-changing aspects of Astronomy Camp. A weeklong summer camp is a large fraction of a teenager's life and can be tremendously influential. The underlying reasons for our success were revealed by a Master's level research study (Deborah A. Fields, 2002) of the Advanced Teen Camp:

- A youth-centered, personal approach by the entire Astronomy Camp staff, treating youth as colleagues rather than children;



Astronomy Camp

**In one of our GSUSA workshops, Girl Scout leaders classify galaxies.**

- Authentic scientific inquiry with realistic projects involving modern research telescopes, technology, and equipment;
- Real scientists as mentors;
- Student peers with common interests in science and engineering;
- A fun attitude toward learning, exploring ideas, and searching for answers;
- The aesthetic qualities of the dark skies of Sky Islands in southern Arizona.

## Girl Scouts and NIRCcam

In 2002, Astronomy Camp had a major opportunity to benefit astronomical research. We proposed an educational partnership with the Girl Scouts of the USA as part of Steward Observatory's NASA proposal to build the Near-Infrared Camera (NIRCcam) for the future James Webb Space Telescope (JWST). Our proposal was accepted and helped secure more than \$300 million to build NIRCcam, with roughly \$1.5 million used to host biannual workshops with Girl Scout leaders to "Train the Trainers." As an aside, our efforts have also led to the phrase "Go Girl Scouts" being engraved onto the optical bench of the NIRCcam instrument. So the GSUSA will be literally going into space!

From the outset we began hosting biannual training workshops for leaders from around the world, not only to train them on specific astronomical topics but also to focus on encouraging young girls in the basic fields of science, technology, and numerical literacy. To date more than 200 GSUSA leaders from 41 US states, Japan, and Guam have attended these workshops, impacting the lives of thousands of Girl Scouts. Our efforts also helped to correct fundamental errors in the official Girl Scout badge materials relating to astronomy. With a JWST launch date of 2018 and a lifetime of approximately 10 years, NIRCcam's education efforts will impact an entire generation of young women.

## Unexpected Benefits

Although Astronomy Camp receives no UA funding, it has contributed financially to the university's mission in both education and research. Several former Campers and their families have donated more than \$1 million toward operating costs and improvements of the Catalina Observatories, and also for major projects such as the entire SkyCenter on Mt. Lemmon and the expansion of the Catalina Sky Survey's research into the discovery and characterization of Near-Earth Objects. Besides the improved publicity and community



Jeff Register

Students measuring the Sun's luminosity with a wax cube and a light bulb.

relations, the university also derives some overhead money associated with these projects.

During more than 100 Camps we have engaged thousands of people from 49 US states and 22 foreign countries, and we remain in contact with many of our alumni. Their motivation continues long afterwards. Surprisingly, more than 60 Camp students enrolled at the UA as undergraduate and graduate students, pursuing subjects both technical and nontechnical. Some of these students are now employed in technical capacities such as telescope operators, computer technicians, programmers, research assistants, etc.

Although the Camps seek only to encourage students to continue their education in science, mathematics, and engineering, they have also motivated students to receive PhD and Masters degrees in astronomy. Each year several former Campers return to serve as Camp counselors and give of themselves to motivate yet another generation. Alumni also contribute funds for scholarships and general operation.

The Camp's model of engaging the public in research has also fostered research-based educational initiatives in the National Optical Astronomy Observatory, the Arizona Radio Observatory, young scientist CAREER grants, graduate and postdoctoral fellowship proposals, and a collaborative education program (CAMPARE) with Cal State-Pomona. It also helped develop a model for local and



Maxine Nagel

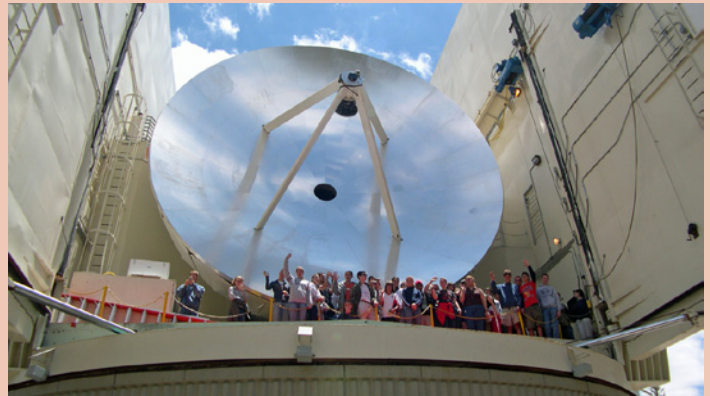
Adult Camper Janet Howard controlling the 61-inch Kuiper telescope. Janet went on to become involved in Citizen Science programs and became a NASA Solar System Ambassador.

national classes in astronomical research through Jeff Lockwood and the Research Corporation. Our model also helped pave the way for future public involvement in major research projects such as the Large Synoptic Survey Telescope and the JWST.

Astronomy Camp has also benefitted our local community in Tucson. We have provided scholarships to the Tohono O'odham Nation and Tucson's Boys and Girls Clubs. In addition, our outreach programs with JWST/NIRCam have supported Southern Arizona's Council of the GSUSA through new STEM activities, graduate student involvement, and the hiring of a STEM advisor (Larry Lebofsky). NIRCam also funds scholarships to Girl Scouts at the Beginning Teen Camp.

## Graduate Student Involvement

Astronomy Camp owes its existence to the creativity and dedication of graduate students, starting with Todd Henry, J. Davy Kirkpatrick, Eric Hooper, and Jeff Register. These students, along with 28 others from Steward Observatory, have invested enormous energy in designing new activities and demonstrations, mentoring students personally and in research, and in the logistics of planning and conducting each Camp. Despite the exhausting effort of each Camp, these students also experience renewed energy and enthusiasm for their research.



Jeff Register

Campers and instructors from the 2004 Astronomy Camp gather in front of the 10-meter submillimeter radio telescope on Mt. Graham for their group portrait.

Compared to the graduate students of 25 years ago, today's grads are a different breed. They view education as part of their development and expect to have experiences like Astronomy Camp during their graduate careers. They seek out such opportunities during their visits to prospective schools.

So what started simply as a fun sideline of sharing astronomy with the public helped begin a new paradigm of science education worldwide — involving the public directly in science instead of relegating them to a classroom. Even more importantly, Astronomy Camp shows the value of “lighting the fire” in both students and staff — allowing them to be creative, and then supporting their efforts. [\[RETURN\]](#)

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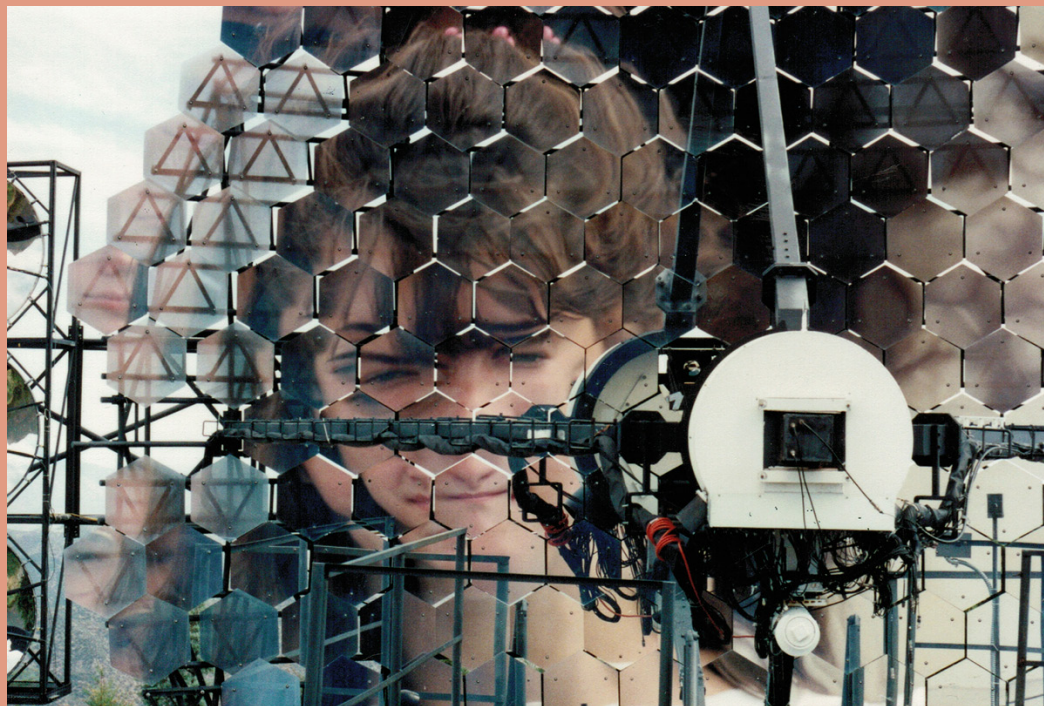
## Personal Stories

**A**n advantage of informal education is the ability to maintain relationships as the years pass. With the perspective of 25 years, we see how events such as Astronomy Camp can affect lives. Here are three examples.

As a high school sophomore, Cyndi Carr attended our first Advanced Teen Camp in 1990. Inspired by the experience, she built a photodiode photometer and coupled it to both her father's

5-inch telescope and the UA's 21-inch telescope for observations of variable stars. She won the regional competition and qualified for the International Science and Engineering Fair. The following year she used the same photometer to study water pollution and again won the regional contest. Cyndi enrolled at The University of Arizona, graduated as the Most Outstanding Senior in Molecular and Cellular Biology, and received her PhD in Neuroscience. Along the way she fulfilled a childhood passion and became Miss Tucson Valley with a community service platform about the importance of science education.

Elizabeth Waterhouse attended her first Camp in 1995. She was such a gifted and driven dancer that she had never thought of graduating from high school. At Camp she observed the Centaur object Chiron with the 61-inch telescope. The following year we replicated NASA's ongoing Roadmap study about searching for extrasolar planets. Elizabeth drafted her team's recommendations and submitted the report to NASA's Director, Dan Goldin. She later enrolled at Harvard majoring in



Cyndi Carr viewing herself at the center of curvature of the 10-meter Gamma Ray telescope on Mt. Hopkins.

Astronomy Camp

physics and astronomy, researched galaxies with Lars Hernquist, and also researched high-mass stars with Philip Massey during a summer Research Experience for Undergrads program at Northern Arizona University. Elizabeth now dances professionally.

Rick St. Clair attended the Beginning Teen Camp in 1994 as a very young teenager with an (over) abundance of energy. He was a discipline problem during Camp. The following year he wrote a near-perfect essay for admission to the Advanced Camp, and after consulting with his teacher, I admitted him. He was a model student! Years later, he e-mailed saying that he was in the Navy's nuclear propulsion program, had been encouraged to become an officer and receive an undergraduate degree in engineering physics, and could I recommend an advisor at the UA? Rick is now seeking his double major in physics and astronomy at The University of Arizona and even became a student "preceptor" in my Cosmology course to non-science undergraduates.

— D. M.