Project ASTRO: 20 Years and Flourishing

By Andrew Fraknoi, Brian Kruse, Rommel J. Miranda, Theresa Moody, and Wil van der Veen.

Volunteer outreach astronomer Brandon Lawton and educator Victoria Mathew work together to cook up a comet at a Project ASTRO professional development meeting. Courtesy Rommel Miranda.

The Astronomical Society of the Pacific (ASP) has had many educational and outreach activities during the years, but Project ASTRO remains the flagship in our fleet of programs. It was the first project for which the Society received federal funding; the first to feature formal, professional evaluation; and the first one to engage three different segments of the Society’s membership — professional scientists, amateur astronomers, and teachers. And it’s still the program whose training and materials have had the most lasting impact nationwide. In this issue, you will read about Project ASTRO from several perspectives. Here, I’d like to introduce the program and tell you a little bit about its history and evolution.

What’s it All About?
Project ASTRO links professional and amateur astronomers with 3rd- to 9th-grade teachers in their communities. After the teacher-astronomer partners are trained together at two-day workshops, each volunteer astronomer “adopts” a class and makes at least four visits during the year. The main focus of the project is hands-on, inquiry-based activities that puts students in the position of acting at discovery — such as using Styrofoam balls to explore the phases of the Moon. [ASP/ Brian Kruse.]
like scientists and helps them reach a deeper understanding of the universe (and science in general) at their own level.

Note that Project ASTRO is not a curriculum in astronomy. There are no prescribed activities or topics to cover. Each partnership draws on its own strengths and interests to plan the astronomy being taught — what happens during each astronomer visit fits with the partners’ own vision of what might be best for the children. As part of the training, the ASP provides each partner with a practical How-to Manual, and with a rich notebook of activities and teaching resources called The Universe at Your Fingertips. Partners can select among the materials therein, or draw from their own work or experience as a source of inspiration.

During the Project ASTRO workshop, astronomers and teachers focus on classroom-tested activities that don’t just convey information but get the students to ask questions, formulate hypotheses, and make observations. Examples of our more popular activities are investigating the phases of the Moon (with models and journals), calculating and walking off a scale model of the solar system (unrolling toilet paper squares as your unit of measurement, to the delight of the students), or organizing and classifying beautiful color images of galaxies. Of course, we also encourage the visiting astronomers to talk about their own work and background in science.

With the help of the Institute for Learning Innovation (our evaluators), we learned a lot from observing the first hundred or so partners in action in the classroom, and refined the program based on the first few years of observations. The sidebar (on the next page) shows you some of the characteristics of successful partnerships, and to no one’s surprise, the lessons learned are very similar to what

Though perhaps not as delightful as the toilet paper solar system activity, using a roll of paper tape to illustrate the vast distances between the planets is just as helpful. [ASP/Brian Kruse]
most of us take away from successful dating!

In the early days a substantial number of our volunteer partners were amateur astronomers, and there was some concern about whether they would have enough background in astronomy to be effective partners in the classroom. But our evaluators found that after Project ASTRO training, amateurs (as well as graduate students) were every bit as effective in the classroom as research scientists. After all, at the fifth grade level, it is rarely important to explain the detailed physics of black hole accretion-disk mechanisms or model stellar atmospheres. Indeed, it turned out that amateurs were often more ready to clarify some basic issue in observational astronomy, such as when will Venus be visible or what kind of telescope might my family buy, than very specialized professionals.

For an astronomer getting ready to face 30 pairs of 12-year-old eyes for the first time, the concern is rarely “Do I know enough about astronomy?” and much more often, “Can I present astronomy in ways the kids will understand and enjoy?” And not knowing an answer to a question is a wonderful opportunity to get the students to think about how to find that answer for themselves.

While Project ASTRO began with a pilot project run by the ASP in California, today there are regional ASTRO training sites around the US. Each site is managed by a lead institution, which appoints a local Project ASTRO coordinator. Many sites rely on a coalition of local scientific and educational organizations to help the lead institution share the work, find financial and in-kind support for the project, identify new partners, and put on regional workshops and follow-up programs for the partners.

**A Little History**

I should mention that, while I had the pleasure and privilege of founding and leading Project ASTRO, its success should be credited

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**Some Key Lessons from Project ASTRO (and their Similarity to Relationships!)**

- Students learn best when they are actively engaged (especially using hands-on, inquiry-based activities).
- There’s no need to reinvent the wheel: good classroom activities/materials already exist.
- Not all topics in astronomy are equal (or, at least, not of equal interest at the K–12 level).
- Finding and matching astronomer and teacher partners turns out to be a more complex and time-consuming experience than we anticipated (all matchmakers know this).
- It’s good to put expectations and commitments into writing (like a pre-nuptial agreement).
- Astronomers and teachers work together best when they are treated as equal partners.
- The success of a visit is generally proportional to the time spent planning it.
- Visiting the same classroom several times (instead of different classrooms each only once or twice) was a more satisfying and effective experience for astronomers and students (one night stands are rarely better than ongoing relationships).
- Ongoing feedback and support is important for both partners (as it is in any relationship).
- For a Project ASTRO site to work in a sustained way, the leadership must want to do the project, not have it imposed on them from a higher authority.
- Everything in the K-12 classroom (and perhaps life itself) takes more time than you anticipate.
to a whole team of creative people. Foremost among them is Dennis Schatz, an astronomy educator from the Pacific Science Center in Seattle (later the first informal-science educator elected President of the ASP), who helped us brain-storm many of the key aspects of the project and create many of its most successful hands-on activities. Michael Bennett, a planetarium educator, college astronomy teacher, and (later) ASP Executive Director, was instrumental in helping us understand the level of support needed by partners some distance away from a training site.

And throughout the project, we had help organizing the complex logistics and “hand-holding” required to create and sustain a national organization from a series of Project ASTRO coordinators, each of whom added their personal stamp and many hours of work beyond the job’s announced requirements. So a big “Thank You” to Jessica Richter (1993-96), Shannon Lalor (1996-2000), Erica Howson (2000-02), Dan Zevin (2002-07), and Brian Kruse (2009 to the present).

Project ASTRO emerged from a confluence of programs the ASP was pursuing in the 1980s, including national workshops for K-12 teachers and programs to get amateur astronomers more engaged in public education. I have recently described some of this early history in an article on the ASP’s website, so I will not repeat it here.
Suffice it to say that our pilot project in Northern and Southern California, supported by the National Science Foundation from 1993 to 1995, went well enough that the NSF then gave us additional funding to expand Project ASTRO nationwide. One interesting byproduct of the first few years were three satellite projects, where astronomer partners who had become especially excited by their role in Project ASTRO had asked our permission to set up some mini-training for a small number of astronomer-teacher partners at their own institutions (in Stockton, Santa Barbara, and Sacramento, California.) This gave us a bit of a preview of how the program might be replicated away from “ASTRO Headquarters.”

In 1996, we put out a call to find astronomy and astronomy education organizations that might want to start their own regional ASTRO training site and found considerable interest around the country. The first two expansion sites were located in Chicago, Illinois (at the Adler Planetarium), and Tucson, Arizona (at the National Optical Astronomy Observatories). Since then, many other regional sites have joined the program; some for a short while, others on a more permanent basis.

By 1999, about a dozen active sites were training some 200 partners a year, and the total number of students impacted by the program since its inception was rising toward 100,000. As funding from NSF ran out, each site was required to find its own financial support locally, either from the lead institution or from their local coalition of supporters. This proved quite a challenge, but many sites managed the transition from federal to local funding with imaginative solutions, including getting local businesses involved, charging school districts for the workshops, finding wealthy donors, and enlisting help from other educational programs (including NASA projects and missions).

**Family ASTRO**

In the meantime, we were noticing that one of the unintended (but intriguing) consequences of Project ASTRO was additional involvement (in many schools) by the students’ families. For example, when local amateur clubs held an evening star party for the Project ASTRO class, even parents who rarely participated in school-parent events were excited enough to come look through the telescopes. Many teachers sent Project ASTRO activities home and encouraged students to share them with their parents and siblings, generating much positive response.

From observing these family interactions, we were inspired to begin a new Program, Family ASTRO, specifically targeted at helping family members enjoy astronomical exploration together. We received a third NSF grant to develop activities, kits, and games that families could do in unison, and to train Project ASTRO site leaders and individual partners on how to use these materials during family evenings or weekend programs.
Eventually, we were also “adopted” by a professional game company, called ImaginEngine, which helped us produce several family-oriented, educational games that were significantly more sophisticated than what a group of astronomy educators could have created by themselves. (The games are still available through the ASP’s AstroShop.)

I remember one of the board games, called Moon Mission, especially fondly, because the only way to win was for family members to cooperate instead of compete. This went so much against the grain of what kids are taught in our culture (in games and sports) from a very young age, that all of us had to get used to a new mindset in playing and teaching the game. But once the families in our test groups became familiar with the idea, they had a great time working together to be victorious on the Moon.

A Gateway to Science

As more and more sites across the country decided to join us, communication between the sites (and with the national office at the ASP) became more complex, but ever more necessary. To help each other, encourage the development of new sites, and foster cooperation with other astronomy education programs across the US, the regional site directors and coordinators formed a national network in 2000, which meets annually and keeps in touch through e-mail and teleconferences. Because the members of the network have access to a national pool of interested teachers, students, and volunteer astronomers, the network is an excellent partner for any astronomy education or outreach project that is developing new educational materials, trying innovative approaches to astronomy teaching, or seeking some training for its graduate students or educational staff on hands-on techniques. People from many programs have observed Project ASTRO training workshops, and several astronomy education projects have put funding aside to use the network to test and use their materials.

In 2001, we began to work seriously on a project that we had been merely experimenting with earlier — translating the activities and materials from Project ASTRO into Spanish for use in other countries and with bilingual populations in the US. For example, the Tucson ASTRO site had a satellite branch in Chile, where some of the NOAO observatories were located, and they were eager to have at least the most popular activities translated into the local language. By 2002, with a little extra help from NSF, we had translated the most popular materials in the project and published El Universo a sus Pies, a compilation that is still in use in many Spanish-speaking parts of the world.

Today, our program is as diverse in its approach as the regions it covers. The regional sites are disseminating Project ASTRO to inner-city schools, rural settings (including Native American reservations), as well as home-school groups. Some sites focus on Project ASTRO in schools, others (such as Hawaii) are doing wide-ranging family programs, while still others are integrating our astronomy activities and approaches into education and outreach programs with a broader focus.
As the years passed, many of our teachers went on to champion astronomy in their schools and districts, and a number of our astronomers have found their calling in education. Noted “graduates” of Project ASTRO include Yale professor and world-renowned planet hunter Debra Fischer; Gibor Basri, an expert on brown dwarfs and the Vice Chancellor for Equity and Inclusion at the University of California, Berkeley; planetary astronomer (and frequent media personality) Heidi Hammel; dwarf-planet discoverer extraordinary Michael Brown (of Caltech); and Isabel Hawkins of the Exploratorium, who recently won the ASP’s Klumpke-Roberts Prize for her national work in education and outreach.

Each time the national science standards and frameworks in the US are revised, we all tremble as we gauge how much or how little astronomy teachers and students will be expected to know. But ultimately, as Project ASTRO enters its third decade of operation, we remain confident that the inherent interest of our subject matter, and the nifty hands-on activities we train our partners to use, will continue to make us one of the most effective gateways to the joys of science for students of all ages.

If you'd like to learn even more, please visit our Project ASTRO webpage.

ANDREW FRAKNOI was the ASP’s Executive Director from 1978 to 1992 and founded Project ASTRO and Family ASTRO. Currently, he is Chair of the Astronomy Department at Foothill College, Vice-president of the Lick Observatory Council, and a member of the SETI Institute Board of Trustees. In 2013, the National Science Teachers Association gave him the Michael Faraday Award for Science Communication.
What Makes a Project ASTRO Partnership Successful?

Successful teacher/astronomer partnerships seem to have five common characteristics.

by Theresa Moody and Brian Kruse

You are about to embark on a rewarding and sometimes challenging partnership to improve science education. These words, from the Project ASTRO How-To Manual for Teachers and Astronomers, encapsulate what it means to be a Project ASTRO partner.

For the past 20 years, the Astronomical Society of the Pacific’s Project ASTRO has partnered educators with volunteer astronomers with the goal of enriching students’ astronomy experiences. Historically, the vast majority of participating educators have been teachers of grade 3-8 students, though all K-12 educators, including those in after-school and community settings, are welcome to participate.

Astronomers have come from various backgrounds. Many are professional astronomers and university faculty, or they are post-doctoral, graduate, or undergraduate students. About half the astronomer partners are amateurs active in their local clubs. Even with this varied background in education and outreach experience, astronomers come to Project ASTRO with a common love of sharing.

Students in Megan Gover’s second grade class built simple spectrographs using aluminum foil, toilet paper tubes, index cards, small pieces of diffraction grating, and tape. The students were encouraged to look at the florescent lights through their diffraction grating material before installing it in their spectrographs. [Courtesy Megan Gover and Susan Benecchi.]
their knowledge and skills at bringing the wonders of the universe to others.

Getting a partnership started, and keeping it going, is not always easy. A few Project ASTRO partnerships never do get off the ground, and many of them last only a year or two. Some are more enduring, continuing to work together for several years. Others have stood the test of time, with partners who carry on working together even after more than a decade has passed since their initial partnering. Regardless, a successful partnership is not necessarily defined by the length of time they endure, but rather by the lasting impact the partnership has had on the students, teacher, and astronomer.

To gain a better sense of these lasting impacts, we asked teachers and astronomers involved in Project ASTRO to write a short description of their partnership, and describe what made their partnership successful. We received many replies, and have selected one of them for you to read (see page 31). From these responses, several attributes of successful partnerships emerged: Friendship and Respect, Communication and Planning, Personal and Professional Benefits, Joy, and a Ripple Effect into Additional Outreach.

**Friendship and Respect**

Astronomers and teachers from successful partnerships described how their working relationship has developed over time into a friendship and how the partners have genuine respect for the skills each brings to the table. Teachers and astronomers used words like “chemistry,” “camaraderie,” and “mutual respect,” and described how much they enjoy spending time talking, planning, and reflecting with each other.

_We get along very well, so I really enjoy working with Rennie [Watson]. She has a science background, so she’s very aware of where I’m coming from. She’s very flexible and does a fantastic job of helping me find topics that I’m comfortable with teaching and passionate about sharing, but also fit into her curriculum…. We also have good communication. At lunch or the end of the day we dissect what worked and what didn’t, and I make notes so I can tweak the lesson for the next year. Then over the summer we meet, review the previous year, and talk about what we want to do for the next year. It’s really nice to be partnered with someone you enjoy having a coffee with!_ Matthew Knight (Astronomer).

**Communication and Planning**

Other common attributes described by Project ASTRO teachers and astronomers were the importance of trust, communication, planning new things, and developing a routine together. Partners spoke of how important it is to regularly communicate, be flexible and accommodating, give feedback, take notes, and meet to plan new sessions. They enjoy the thrill of tweaking classic activities to
improve them and also being adventurous enough to try new things together. There is a need for trust that each partner will come prepared to fulfill their role in the investigation, always with the students’ best interests in mind.

There is also an aspect of trust. We are each so busy that when a plan has been made to meet at a certain time and accomplish some task, each has to trust that the other will be there, prepared for the task at hand. Finally, we each have a sense of adventure. We have found activities that work, but we are always ready to try something new. We both have an adventurous spirit, and our natural curiosity promotes creative thinking and innovative lessons. Tom Krause (Astronomer) and Trish Stadler (Teacher).

**Personal and Professional Benefits**

It was clear in every partnership that the teacher and the astronomer felt they received both personal and professional benefits. Astronomers most frequently commented on how their Project ASTRO experience gave them a chance to see and remember their own enthusiasm for astronomy, a chance to share their own passion and knowledge, and a reminder that science is fun. They described the thrill of being back in the classroom, how rewarding it is, and the little moments when they know the effort has been worthwhile.

It’s quite a bit of work for me before each class: Going over the lesson to make sure it’s pitched to the right level, that it will last an appropriate amount of time, coming up with contingency plans if it goes too fast/slow, buying supplies and prepping them so the kids don’t waste too much time, etc. Throw in commuting…and a full day teaching, and each class visit really takes two full days of my time. Multiply that by three or four class visits over a month and this is a big hit to my productivity each winter.

As I don’t yet have a permanent position in astronomy, I am under a lot of pressure to publish and write proposals. So every year the pressure from the amount of missed research time builds up inside and I think, “Is this really what I should be doing with my time?” Then I teach, and I completely forget all of the things I was worrying about! For a whole day I am reminded of how much fun science is. I leave at the end of the day exhausted but flying high. Matthew Knight (Astronomer).
One thing of which I have been made acutely aware is this: In the second grade everybody wants to be a scientist. A few years ago I was sitting in a doctor’s waiting room, and a young boy kept staring at me. I was a bit curious until finally his mother came over and said: “You helped him build a telescope.” Oh! Did that feel good! So I talked with him about the telescope and about Ms. Trish’s class. And I left with the feeling, “Wow! I guess it is all worthwhile!” Tom Krause (Astronomer).

Teachers most frequently commented on how their Project ASTRO experience built their confidence and knowledge in the content, improved their practice in the classroom, and how thrilling it is for them and their students to work with an expert.

The biggest wow moment for me was when [Astronomer] Russ Drum and I were preparing for the lesson ‘The reasons for the seasons.’ When he tilted the pencil and moved it around his head, the light bulb went off and I understood — the tilt! There are so many times when we work together, the light for me goes off, and then I can help get that point across to the students in preK-5.… He said to me, it is because of your first step that so many students got a chance to learn about the stars. I was honored. It is his patience that kept me, and the students, fascinated and always looking into the night sky. Brenda Cook-Johnson (Librarian).

I’ve gained more confidence in teaching space sciences. Through Project ASTRO I was able to attend teacher workshops offered during an Astronomical Society of the Pacific conference held in Baltimore. It was wonderful to discover ways to create hands-on learning experiences for space science lessons. I used to think, “How am I going to teach this stuff? Everything is so far away.” Rennie Watson (Teacher).

Joy

The fourth of the common characteristics described by successful partnerships was that both teachers and astronomers were amazed at the amount of joy the experience generated for all involved. Both described how students bubbled over with questions to be answered, and how their enthusiasm was barely containable.

The best thing has been watching students respond to [Astronomer] Matthew Knight. They love when he visits and always want to know when he will return. Both of us hope that working with him inspires students to consider careers in astronomy. Rennie Watson (Teacher).

After [Astronomer] Tom Krause built Galileo telescopes with the class, there were quite a number of parents that came to me to find out where to buy these telescopes. Their kids were begging for scopes. Also, my students think Tom is related to Albert Einstein. Trish Stadler (Teacher).
One of the best things about our partnership is that we are all really excited to be a part of it! We all enjoy finding new and innovative ways to tie our individual passions together with current astronomical events and news to create hands-on, project-based experiences for the students. Linda Scarth (Teacher).

Ripple Effect into Additional Outreach

The fifth and last of these common attributes of successful partnerships was, for the astronomers, how outreach through Project ASTRO had rippled into additional outreach elsewhere. Many astronomers described new trips, expanded star parties, and other events and projects and/or partnerships they had taken on as a natural extension to the work they had done with Project ASTRO.

In some cases, this was expanded to other content areas within the same school, as was the case for Nikole Manou (Teacher) and Roy Hayter (Astronomer). Roy quickly found himself helping in Nikole's 5th grade classroom during chemistry lessons (his area of expertise) and in her 4th grade classroom doing Newton's Laws of Motion, as well as planning additional star parties and a trip to a tech museum and a college planetarium.

Perhaps the greatest ripple effect we've seen is the creation of new Project ASTRO sites by astronomers who were partnered with teachers and then moved on to a new position in a new state that did not have an active Project ASTRO site. This has happened twice in recent years: Karen Vanlandingham and Jennifer Scott, both former astronomer volunteers in Tucson, are now both site leaders in new states.

When I was teaching as an adjunct faculty member at the University of Arizona I got involved in the local Project ASTRO program and was paired with a couple of 3rd grade teachers. The teachers were awesome and working with the kids was so much fun! We would do phases of the Moon activities with Styrofoam balls in darkened classrooms and you could hear the kids going “Ohhhhhh!” as the connection between the position of the Moon, Earth, and Sun and the observed phases finally clicked. What a great moment!
A Partnership: In Their Own Words

Debbie Dickinson (Teacher, Old Farmers Road School, Long Valley, NJ): Our partnership thrives because Bob and I share similar values. It is obvious we both are interested in astronomy, but it goes way beyond that. It appears to me that we both possess an unquenchable need to provide students with experiences that will enrich the given curriculum, but more importantly, their lives! Another vital contributor to our success is a mutual respect for each other and the students. We work together, mindful and considerate of each other’s unique perspective, to provide the most beneficial inquiry-based experiences for our students. It is also very helpful that Bob interacts and relates to the students at whatever level they are at. His pleasant, warm, and down-to-earth demeanor makes the children feel comfortable and willing to ask questions.

Patience and understanding also play an important role in our partnership. Bob’s expertise and enthusiasm are astounding! His exuberance can be a bit overwhelming for me as I am more reserved and like to have a secure handle on things before I take the plunge. Bob always gives me the time and information I need to “get my ducks in a row” without making me feel incompetent or like a nuisance. I try not to quell his enthusiasm with my constant questions and need for clarification!

I believe my students and I have benefitted from my Project ASTRO partnership with Bob in immeasurable ways. I have definitely increased my knowledge and understanding of astronomy, life, and myself. Having the opportunity to work with someone in my class has made me reflect on my teaching style and practices. Project ASTRO’s lessons/activities affirm my belief that students grow and learn best from inquiry and problem-based, hands-on learning.

Also, two heads are better than one! Bob’s brains and my know-how complement each other during planning and in the classroom, as well as provide my students with an extraordinary opportunity and enrichment they would not otherwise receive as part of the regular curriculum.

Finally, as a result of my Project ASTRO relationship with Bob, I have acquired a friend and mentor. Bob’s vast experience and perspective of life has afforded me a new and objective way of looking at, and dealing with, situations that occur.

Bob Reichman (Astronomer): I’m a late-blooming amateur astronomer, and I’ve kept myself busy in astronomy outreach since the 2009 International Year of Astronomy. Since that time I’ve been a part of four Project ASTRO partnerships. My fourth and newest partnership is great, and our program is growing smoothly in its third year.

Debbie and I hit it off from the moment we introduced ourselves at a two-day Project ASTRO workshop here in New Jersey. She’s very personable and outgoing with a strong enough sense of self that I didn’t intimidate her as I do many people. My direct communication style and twisted humor didn’t faze her. We scheduled the entire year of class visits, including a star party, before the Saturday afternoon workshop wrapped up. I think the world of her, and we’ve developed a friendship and mutual admiration for one another. She can’t believe my willingness to come into her classroom four or five times a year and share my joy and passion for things astronomic with her and her students. I can’t believe she and her principal let me.

The bases for our continued successful partnership is respect, clear and direct communication, and thorough planning. Because of divergent schedules, we don’t speak on the phone a lot but do most of our back-and-forth via text or e-mail. We’re respectful of each other and responsive to each other. For instance, when planning our first star party Debbie expressed a concern for being overwhelmed by all the details, but we landed on a size, scope, and complexity with which everybody involved could be comfortable. We now have plans for our next star party, which is three times larger with many more moving parts. She is ready to go and comfortable taking on this far larger program.

The extent of my astronomy outreach has gone supernova since I began with Project ASTRO. Because of it? Probably not, but certainly buttressed by the great feedback I enjoy through my Project ASTRO classroom experiences. Since Project ASTRO, my additional outreach activities have grown to include volunteering for a month each fall as a Dark Ranger at Acadia National Park; sharing telescope skills and demonstrating inquiry-based, astronomy activities with public school teachers; visiting schools, libraries and nursing homes; and most recently learning about planetarium operations at a local community college.

Our partnership is a great example of one in which everyone benefits.
Ultimately I got a job at West Chester University (PA), and when I was packing up to move, I figured I would sign up for the local Project ASTRO once I got out east. Imagine my disappointment when I found out that there wasn’t a local office near me! Knowing how much the students, teachers, and astronomers got out of the program, I decided to look into building a new Project ASTRO site at West Chester. Six years later we’ve managed to create several dozen teacher-astronomer partnerships. Karen Vanlandingham, Project ASTRO site leader, West Chester, PA.

When I arrived in Baltimore as a post-doc in 2002, I began to think about how the Project ASTRO model might serve both the perennially challenged Baltimore City Public Schools and the many astronomers and astronomy experts in our region. It seemed such a shame that the vast intellectual resources and enthusiasm of these folks were not tapped for the purpose of drawing more kids into science.

It wasn’t until I began a position on the faculty of Towson University that I had the opportunity to realize this dream. The success of our program means many astronomers are as eager to reach out to students as I was as a graduate student. Jennifer Scott, Project ASTRO site leader, Baltimore/Towson, MD.

“You are about to embark on a rewarding and sometimes challenging partnership to improve science education.” Each of the partnerships described (and thousands more) have undertaken this journey during the 20 years since Project ASTRO began. Those teachers and astronomers who describe their partnership as successful have commented on the important attributes that kept their Project ASTRO going. Thousands upon thousands of students have had their lives touched in a positive way by the thrill of astronomy. The sky is certainly no limit for the next 20 years of Project ASTRO.

THERESA MOODY is the Program Manager of the New Jersey Astronomy Center at Raritan Valley Community College, where she facilitates various teacher professional development opportunities in science and astronomy. She manages the New Jersey Project ASTRO site.

BRIAN KRUSE is the Lead Formal Educator at the Astronomical Society of the Pacific, where he coordinates the Project ASTRO National Network and manages San Francisco Bay Area Project ASTRO.

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Susan Benecchi (astronomer) & Megan Gover (teacher, Mount Washington School, Baltimore, MD).


Russ Drum (astronomer) & Brenda Cook-Johnson (Librarian, Summerfield Elementary School, Neptune, NJ).

Roy Hayter (astronomer) & Nikole Manou (teacher, Lucile M. Nixon Elementary, Palo Alto, CA).

Rich Huber and Linda Prince (astronomers) & Linda Scarth (teacher, Copiague Public Schools, Long Island, NY).

Matthew Knight (astronomer) & Rennie Watson (teacher, Academy of Science, Baltimore, MD).

Tom Krause (astronomer) & Trish Stadler (teacher, Medfield Heights, Baltimore, MD).

Bob Reichman (astronomer) & Debbie Dickinson (teacher, Old Farmers Road School, Long Valley, NJ).

Mike Smithwick (astronomer) & Kofo Oluwole-Orojo (teacher, Majestic Way School, San Jose, CA).

Jennifer Scott, Project ASTRO site leader, Baltimore/Towson, MD.

Karen Vanlandingham, Project ASTRO site leader, West Chester, PA.
For at least the next decade, the Next Generation Science Standards (NGSS — *Next Generation Science Standards: For States, by States*) will likely affect all aspects of science teaching and learning, including astronomy. The NGSS presents a new vision for science education and is based on *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC 2012). This Framework provides our best understanding of how our nation's students learn science and what is needed to create a competitive 21st-century workforce. The Framework further provides justification for the conceptual shifts that the NGSS presents, and helps to illuminate what is new and different about the NGSS compared to current classroom practices (*NSTA 2013 position statement*).

The main impetus for the NGSS and the Framework is the idea that K–12 science instruction be built around three dimensions that are intertwined and mutually supportive: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas.

**Dimension 1: Science and Engineering Practices.** The eight science and engineering practices are derived from practices that scientists and engineers actually engage in as part of their work.

Volunteer outreach astronomer Matthew Knight works with Rennie Watson’s Earth and Space Science class to create and learn how to use star charts to find constellations. [*Courtesy Rennie Watson.*]
They build on the principles of inquiry-based learning, but expand on them in several important aspects such as “Developing and Using Models” and “Engaging in Argument from Evidence” which are usually under-emphasized in an inquiry classroom.

**Dimension 2: Crosscutting Concepts.** The seven crosscutting concepts describe concepts that bridge disciplinary boundaries and have explanatory value throughout much of science. They help students connect knowledge from the various disciplines into a coherent and scientifically based view of the world. These crosscutting concepts provide excellent opportunities for students to make connections between content across disciplines and provide lenses for looking at the natural world.

**Dimension 3: Disciplinary Core Ideas.** Given the wealth of scientific information available today, an important role of science education is not to teach “all the facts” but rather to prepare students with sufficient core knowledge so that they can later acquire additional information on their own. Thus, an education focused on a limited set of ideas should enable students to evaluate and select reliable sources of scientific information, and allow them to continue their development well beyond their K–12 school years as science learners, users of scientific knowledge, and potentially producers of such knowledge. Accordingly, the Framework describes 13 core ideas in science and engineering: four in physical science, four in life science, three in Earth and space science, and two in engineering, technology, and applications of science. Such a limited set of core ideas allows for in-depth learning of these ideas as students engage in science and engineering practices and use crosscutting concepts to develop their understanding of these core ideas over time.

The NGSS also includes Performance Expectations (PEs) that integrate the science and engineering practices with the crosscutting concepts and disciplinary core ideas. These PEs require that students demonstrate their understanding of science by using and applying their knowledge. Although not all states are expected to adopt the NGSS, the Framework that serves as its foundation will likely affect future state standards for at least the next decade.

**Astronomy Education and the Next Generation Science Standards**

To better understand the implications of the NGSS for astronomy education, it is essential to take a closer look at how astronomy is represented in the NGSS. One of the 13 core disciplinary ideas directly relates to astronomy. This core idea, named “Earth’s Place in the Universe”, is divided into three component ideas: “The Universe
and Its Stars,” “Earth and the Solar System,” and “The History of Planet Earth.” However, only the first two component ideas are typically taught as part of an astronomy unit. In the NGSS, astronomy can be divided into five sub-topics, which include Earth-Sun-Moon System, Sun and Stars, Gravity, Solar System, and Galaxies and the Universe.

• Ideas about the Earth-Sun-Moon System are introduced in the 1st grade and further developed in grade 5 and grades 6–8; four of the 12 astronomy PEs target these ideas.

• Ideas about the Sun and Stars are introduced in the 1st grade and further developed in grade 5 and grades 9–12; four astronomy PEs target these ideas.

• Ideas about Gravity are introduced in the 5th grade and further developed in grades 6–8 and grades 9–12; three astronomy PEs target these ideas.

• Ideas about the Solar System are introduced in grades 6–8 and further developed in grades 9–12; three astronomy PEs target these ideas.

• Ideas about Galaxies and the Universe are introduced in grades 6–8 and further developed in grades 9–12; two astronomy PEs target these ideas.

The choice of the elementary grade levels (1 and 5) and the content per grade level is intentional to ensure that students have the required prerequisite knowledge to understand these astronomy ideas at a deeper level. Only 12 PEs are directly related to astronomy: two in the 1st grade, three in the 5th grade, three in grades 6-9, and four in grades 9–12. Examples include:

• Grade 1: Use observations of the Sun, Moon, and stars to describe patterns that can be predicted.

• Grade 5: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

• Grade 6–8: Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.

• Grade 9–12: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Although each PE includes only one of eight science and engineering practices and one of seven crosscutting concepts, a unit or sequence of lessons to prepare students for such a Performance Expectation should include most or all of them. Nevertheless, it is illustrative to examine which practices and crosscutting concepts are most frequently included in the astronomy PEs and are considered to be especially important for deepening students’ understanding of the content addressed in those PEs.

The following practices are most often included in astronomy PEs:

• Analyzing and Interpreting Data (three),

• Developing and Using Models (three), and

• Engaging in Argument from Evidence (two).

The other five practices are included one time each, except for “Asking Questions” which is not included in any astronomy PEs.

The following crosscutting concepts are most often included in astronomy Performance Expectations:
patterns (four), scale, proportion, and quantity (four), and energy and matter (two).

Two crosscutting concepts — cause and effect, and systems and system models — are included one time each, and the remaining two crosscutting concepts — structure and function, and stability and change — are not included in any astronomy PEs.

**Project ASTRO and the Next Generation Science Standards**

To remain relevant in our nation’s dynamic educational environment, the Astronomical Society of the Pacific’s Project ASTRO will have to adapt to support teachers with the implementation of the NGSS. The NGSS presents a number of challenges as well as opportunities. Astronomy is only a very small part of the NGSS. In elementary school, students learn about astronomy only in grades 1 and 5, and are held accountable for only five PEs. Although astronomy is better represented in middle school and high school, it is rarely taught in our nation’s high schools except maybe as an elective. Thus, there is the danger that astronomy will not be taught to students, even as part of the NGSS, especially if it will be a very small part of high-stakes testing. On the other hand, astronomy as one of the applied sciences is an excellent vehicle for use and application of knowledge, and an important goal of the NGSS. Additionally, astronomy continues to fascinate students of all ages.

So what can we do to ensure that astronomy remains an integral part of the K–12 curriculum? First, we will need to examine all the astronomy activities and investigations currently used and assess how well they are aligned to the NGSS. Project ASTRO is rightly proud of its *Universe at Your Fingertips (UAYF)* DVD resource. It contains more than 150 astronomy activities that, during the past two decades, have moved teachers and their students away from reading about astronomy toward doing astronomy.

Now is the time to think about how we can modify these great activities and transform them into exemplary investigations that are aligned with the NGSS. We have to determine which of the *UAYF* activities best support the core ideas in the NGSS and how to sequence these activities to support individual astronomy PEs.

We have to consider how to modify these activities so that students will engage in science and engineering practices and select and use crosscutting concepts to make sense of astronomical phenomena. At the very least, the practices of Analyzing and Interpreting Data, Developing and Using Models, and Engaging in Argument from Evidence — and the crosscutting concepts of Patterns; Scale, Proportion, and Quantity; and Energy and Matter — should be emphasized based on the frequency at which they are included in the astronomy PEs.
Second, we will have to provide high-quality professional development for our volunteer astronomers and in-service teachers so that they understand the conceptual shifts presented by the NGSS. This will also present a major shift for our volunteer astronomers and for scientists in general. Scientists are used to being a source of information, but now we need to tap into their experience with science practices and using knowledge to create new knowledge. We need to provide them with the tools so that they can model this for teachers and students and engage them in astronomy. Accordingly, scientist-educator partnerships will need a significant amount of support to implement the NGSS.

Moving Toward a Transformative Educational Research Agenda

During the past two decades, scientist-educator partnership programs have rapidly emerged across the United States with the goal of enhancing the teaching and learning of science to students in our nation’s schools. The National Research Council has noted that scientists play a critical role in achieving a vision of a scientifically literate populace. Reports also suggest that K–12 science education could be strengthened if scientists partner with teachers in local area schools to share their knowledge, passion, and expertise in science with students (Linn et al., 1999; Munn et al., 1999; Wheeler, 1998).

Although many published articles and reports often describe the outcomes of scientist-educator partnership programs anecdotally, the influence of scientist-educator partnerships on the teaching and learning of science to students has not been well documented in the extant research literature. Given the lack of empirical evidence, a more comprehensive understanding of the influence of scientist-educator partnerships is vital, especially for designers and facilitators of such educational programming.

In the same vein, Project ASTRO has been linking professional and amateur astronomers with local K–12 teachers and students to bring inquiry-based astronomy activities to classrooms during the last 20 years. Project ASTRO is an example of a successful model for astronomer-educator partnerships (Fraknoi et al., 1998) that has been sustained for many years beyond extramural funding, and has been listed among the most effective programs in the United States involving scientists and engineers in K–12 education (Connolly, 1997). In its first 10 years of operation, Project ASTRO served more than 100,000 students (Fraknoi and Zevin, 2003). Research studies suggest that teachers participating in Project ASTRO believed that their partnership with an astronomer positively influenced their...
students' behaviors, and their students' attitudes toward science (Gibbs and Berendsen, 2007; Miranda, 2012).

Other empirically based studies on Project ASTRO suggest that participating educators believed that their partnership with an astronomer largely influenced their students' level of motivation, increased their students' level of questioning, and enhanced their students' learning experiences in astronomy by making the subject area more realistic, relevant, and scientifically rigorous (Miranda, 2010; Miranda, 2012). The implications of these findings suggest that astronomer-educator partnerships may enhance students' learning experiences in astronomy and promote their engagement with science.

While the programmatic goals of Project ASTRO make a great deal of intuitive sense, the program generally lacks empirical evidence or validation. When we reviewed the literature base for articles on Project ASTRO, we found it difficult to find papers with clearly articulated research questions, or specific details regarding how programmatic data would be collected, analyzed, and assessed. Consequently, this demonstrates the inherent difficulty in determining the overall success and effectiveness of Project ASTRO, since many manuscripts in the extant literature base often present programmatic outcomes anecdotally. Thus, the continued expansion and emphasis for a research agenda on Project ASTRO is vital to help create new knowledge that can impact K–12 students and teachers, as well as astronomy education at a national level.

Based on our background as science education researchers and as professional development providers, we strongly encourage facilitators of astronomer-educator partnership programs in K–12 schools to take a more critical, empirically-based research perspective to assess their programmatic goals. Additionally, they should plan to disseminate their research-based findings with the astronomy education community through local, regional, and national conferences; research and practitioner journals; and popular publications so that they can be used as a basis for discussion.

The Evolution of Project ASTRO
Amidst our nation’s dynamic educational environment, we believe that Project ASTRO can evolve to remain relevant by moving toward a transformative educational research agenda. Although this concept can have multiple meanings, transformative educational research implies a radical change in our understanding of an educational practice and is at the forefront of creating new knowledge as a means to achieve some change in society. This suggests that the societal impacts of transformative research could be done by conducting research on the broader impacts of Project ASTRO on K–12 schools across the nation, integrating research with societal goals of science education such as the NGSS, and through collaborative reflection on the societal effects of Project ASTRO on astronomy education in general as part the evaluation. Only by doing so can we create new knowledge and a more coherent and articulated astronomy education experience for K–12 teachers and students in the US.

During the 2013 Project ASTRO National Network (PANN) meeting in Baltimore, site leaders recognized that an examination of the PANN could provide a unique research opportunity, because each
lead institution’s local coalition of scientific and educational organizations, and the communities they serve, vary from site to site. Accordingly, during the 2014 PANN meeting in Michigan, site leaders plan to systematically assess Project ASTRO’s diverse programmatic structure among Project ASTRO lead institutions (currently active in 12 regions throughout the United States) and their broader impacts on K–12 schools across the nation during the last 20 years. This investigation will be done to specifically generate new research knowledge to support the improvement of science teaching and learning through astronomy in our nation.

Site leaders also plan to share their experiences and values with one another to establish the culture and foundation upon which to build a transformative educational research agenda. Moreover, the findings of this kind of agenda can help to advance our knowledge base in science education by yielding research-based best practices for fostering partnerships that involve astronomers and educators, by yielding research-based best practices for providing professional development for astronomers and educators, and by helping to guide others who may be interested in designing and facilitating programs that involve scientist-educator partnerships that are culturally responsive in their classroom practice.

The implementation of the NGSS in K–12 classrooms across the United States, and the movement toward a transformative educational research agenda, will be a very challenging endeavor. In light of our nation’s dynamic educational environment, we hope that our ideas in this article will get the conversation started in the astronomy education community. The advantage for astronomy is that we are a fairly small community with a relatively small amount of content to cover in K–12. If we can come together and collaborate, astronomy could set an example for other science disciplines to follow.

ROMMEL J. MIRANDA is an Associate Professor of Science Education in the Department of Physics, Astronomy and Geosciences at Towson University. He is co-director of the Towson University "Project ASTRO" institutional site in Maryland, co-Principal Investigator and internal evaluator for the NASA-funded “Baltimore Excellence in STEM Teaching Project,” and co-Editor of the Association for Science Teacher Education Newsletter.

WIL VAN DER VEEN has a PhD in astrophysics from the University of Leiden (Netherlands) and has been involved in astronomy research for more than 15 years. Currently he is the Director of the Science Education Institute at the New Jersey Astronomy Center at Raritan Valley Community College and has been involved with New Jersey Project ASTRO since its inception in 1998. He is also involved in several programs to help prepare for the implementation of the Next Generation Science Standards.

The 2013 Project ASTRO National Network Site Leaders Meeting, hosted by Towson University in Maryland. [Courtesy Rommel Miranda.]