White Papers Submitted
to the
AAS 2016 Task Force on Education

Task Force Members:

Nancy Brickhouse
Kim Coble
Pamela Gay
David Helfand
Sarah Higdon
Charles Liu (Chair)
Alice Olmstead
Ed Prather
Travis Rector
Alex Rudolph

AAS Staff Liaison to the Task Force:

Gina Brissenden

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White Paper Submission to the AAS Education Task Force**

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White Paper on the Power of Images in Astronomy Communications & Education

Kimberly K. Arcand, Chandra X-ray Center, Smithsonian Astrophysical Observatory (SAO)

Introduction

Images have the potential to convey powerful messages to the public. In astronomy, images of space are particularly important as they can serve as powerful tools of communication, education, and inspiration. However, the public's understanding and trust in the veracity of these images is paramount. In an age of easy manipulation of images, and frequent separation of the image from its context, the question arises as to what is perceived as "real" by those viewing images for science communications. Research that seeks to study the concept of "image as truth" in astronomy and related science communications, which also effects representation of such data in educational environments, is a critical component of any forward-looking strategic plan or vision. We argue it is essential in understanding how the astronomical community can use these images as vehicles to deliver the concepts of scientific discovery and the associated excitement to the widest possible audiences.

Background

The Aesthetics & Astronomy group (A&A) at SAO is comprised of astrophysicists, astronomy image development professionals, educators, and specialists in the aesthetic and cognitive perception of images working together to examine how astronomical images are perceived and how they communicate science to the public, whether to educators, students, experts or non-experts. To our knowledge, there is no other research group of its kind, filling a needed role in studying our relationship with and reaction to images of space and beyond. Since its inception in 2008, A&A has published findings related to expert/non-expert differences in perceptions, misconceptions held by the public, emotional responses to images, the use of processed color in images, and how best to communicate content to educate and engage the public, among others (see Smith et al; Arcand et al references).

Research Questions

One aspect of the A&A research program is that it continues to evolve and expand its scope as new lines of questioning reveal themselves based on the findings that are uncovered. There are some common themes in the research that include questions as such:

1. How much do image viewers trust that what is depicted in an image is an accurate representation of the science?
2. How persuasive is the image in terms of visually conveying the intended message?
3. What text information best communicates the intended message for an image, and for which audience(s)?

Underpinning such research is the knowledge that astronomical data can translate into powerful imagery for the public. There is also much discussion in this age of Photoshop about what is "real" in images (Rossner & Yamada, 2004; Schwartz, 2003).

Solution

In its eight years of existence, the A&A group has conducted several studies involving many thousands of participants. The result of these efforts has been dozens of talks and articles, as well as research papers that have appeared in peer-reviewed journals such as Science Communication, Curator, and Studies in Media and Communication. While this work has laid the foundation for what could be a burgeoning field of study, much remains to be done.

The A&A project seeks both additional partners and new sources of funding to examine how to continue its study of this area to better understand how viewers of varying levels of expertise interact with and perceive images from science. Ultimately, this would help establish how best to build confidence in the veracity of the images and comprehension of the scientific information accompanying them.

Establishing the perceptions, misperceptions, emotional reactions, and comprehension of images that have been designed to communicate with the greater public regarding astronomy and related sciences could improve relationships with those topics. Providing initial guidelines on how images and their accompanying text can better communicate the science associated with these important areas should be an area of focus. By developing such "best practices" guidelines, the A&A project has the goal of helping all of those involved with creating and disseminating astronomical images to optimize their efforts and achieve the most desirable results.

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White Paper: Application of Professional Data Processing Tools in E/PO Work.

Bruce Berriman (IPAC, Caltech)
Senior Scientist, IPAC
PI, Montage Image Mosaic Engine

May 27, 2016.

Introduction

Amateur astronomers and educators asked whether they could run the Montage image mosaic engine on the Windows platforms preferred by these user communities. Yet Montage was intended as a tool for professional astronomers, and was only designed to run on common *nix platforms. Thus I have become interested in how professional tools can be extended to support E/PO efforts. The Montage team has begun development of a Windows based version, an effort that is raising some interesting issues I would like to bring to the attention of the Society. Please note that I am a Senior Scientist at IPAC, I work heavily in the software and technology side of astronomy, and I do not teach and am not connected formally with the educational community.

History: Building an E/PO Version of a Professional Tool.

Amateur astronomers and communities of educators with access to small telescopes, generally used by middle and high school students (e.g. through the Skynet network), have requested a version of Montage that ran on Windows. This is needed because these telescopes are equipped with only small CCD chips where a single images covers only part of an extended source. Creating a Windows enabled version itself is not difficult with the Cygwin Windows emulator. What complicates the effort is that, while these communities create data in FITS files, these files contain no image footprint information (WCS headers), and no image calibration, both assumed by Montage. We only learned this through contacts with educators involved in the NASA/IPAC Teacher Archive Research Program (NITARP). We were referred to them by the NITARP lead at IPAC. Armed with this knowledge, we have become positioned to generate a tool that is valuable to educators – we are using astrometry.net to derive WCS information, and developing approximate calibration techniques. **We were only able to understand the needs of these communities through collaborations with experienced educators.** Our technical goal is to integrate Montage into the image processing packages used by educators to enable maximal take-up.

How Can the Society Help Support This Type of Work?

We had to spend a lot of time trying to connect with educators. **Had NITARP not been based at IPAC, we may well never have made these essential connections and never understood the educators' needs.**

This raises the question of how astronomers wishing to connect with E/PO communities to support the use of professional software can do so, especially as NSF proposals require a strong E/PO program. This may be especially important for early career astronomers who have yet to develop an extensive professional network. I would ask the Society to consider the role they play in helping astronomers connect with E/PO communities. For example:

- Hold workshops on best practices for developing outreach versions of professional applications. These can be supported by e.g. successful cases studies and a set of best practices.
- A “Clearing house” to facilitate collaborations? One approach may be a registry of E/PO specialists who wish to collaborate with astronomers. Another may be to supporting “calls for collaborators” when astronomers are developing an E/PO program.

Astronomy's Role in International Relations
White Paper (via email text)
Peter L. Biermann (MPI) <plbiermann@mpifr-bonn.mpg.de>

Looking into the far future the most important aspect is the international competition among different countries for the best, and that includes getting young people motivated from at least age 3 or even earlier. In the far distant future the economies may be ranked by sheer size of population, and if so, then the US will be rank 4, after China, India and Europe. However, as well illustrated by my own family's experience, the US is unique in nurturing the young and gifted. That is a very special US strength, which the US needs to build on, to recognize and support the young. What the US is doing very badly is in the cost of all these steps of education, which means that it gets very few of the best and brightest from among those who cannot possibly afford even the very first step. How could a young woman in northern Myanmar even know about Wellesley College, let alone know about options for funding? Ditto someone from rural Mississippi. That very first step is very haphazard, and the prospective cost is debilitating. Another step where the US is quite irrational is giving a work permit after finishing college, after the quality of someone has been recognized. There are outstanding young people whom their international company moves to the UK or some other country, when for no good reason the US refuses to issue a work permit.

From my experience the conclusions are three-fold: 1) The US should do a whole lot more to motivate, educate, and integrate the very young among its own population, including not just the MINT topics, but also the humanities, since the US needs people who speak and understand other languages and cultures (not understanding other countries can lead to trillion dollar mistakes, and hundreds of thousand of people killed). Such efforts ought to begin at age 3 or even earlier. 2) The US should offer much more generous fellowships to aspirants from itself as well as other countries, with a dedicated program to identify the best and brightest from a really young age. 3) The US should offer to keep the best and the brightest after they finish their education. It ought to be the decision of the young whether they want to go back, move on to another country, or stay in the US. They should be lured not kicked.

Astronomy has the advantage to cover all of physics (higher energy particles than the LHC at CERN; higher energy neutrinos than any accelerator; gravitational waves impossible in any Lab; and photons from the very early universe). Astronomy provides the motivation for very many academic pursuits, especially in physics, chemistry and mathematics. But Astronomy also provides a superb international environment, with a large fraction of all marrying someone from another country, often another continent, with any children then multi-national and multi-language citizens. So Astronomy can play a unique role.

An Important Component for Addressing Pseudo-scientific Claims in Astronomy and other Physical Sciences

William T. Bridgman, Ph.D.

Pseudo-scientific beliefs in astronomy and other physical sciences have proven remarkably stubborn to eradicate. Once considered by the scientific community as a nuisance but ignorable, the alignment of a number of pseudo-science claims with political/religious ideologies is proving to be a dangerous combination which threatens not only the scientific enterprise itself, but the economic benefits derived from a scientifically and technologically literate population. The history of Lysenkoism in the Soviet Union and Deutsche Physik in Nazi Germany teach that the scientific community ignores these types of claims at its peril.

While the scientific community can never hope to eliminate pseudo-scientific beliefs in the general population, it is clear that scientific literacy, like a national infrastructure, must be subjected to continuous maintenance and upkeep. Many of the pseudo-scientific claims popular today (Intelligent Design, Electric Universe, etc.) have their roots in older claims (young-Earth creationism, Velikovsky, etc.) and some can even be traced back to ideas that were once considered legitimate scientific hypotheses a century or more ago.

The problem is complex, and no one solution will be 100% effective. That is why a multi-pronged approach is vital. Organizations such as the American Association for the Advancement of Science (AAAS) has adopted an approach of promoting dialog between scientific and religious communities to identify common grounds for discussion. But other components are needed.

One important aspect of a solution is a quality set of resources for dealing with these claims. Some resources are available in the professional literature, available to those with access to a well-equipped library (such books as “Scientists confront Velikovsky”, or “Scientists Confront Creationism”), but such libraries are generally difficult to access in the places where they may be needed most.

Presently, most of the freely available, online resources for dealing with pseudo-science are developed by individuals, usually on their free time. Many of these individuals have been criticized by mainstream scientists as wasting their time dealing with crank science claims, but the rise of pseudo-sciences tightly coupling to political ideologies has silenced many of those critics. The resources developed by these individuals can be of surprisingly high quality, but may exist or be available for the lifetime, or perhaps the duration of interest of the individual. How many of these resources are lost when the individual loses interest, retires, or dies? Is there any practical way to collect and preserve these resources for review and future reference?

I propose that the American Astronomical Society (AAS), perhaps in coordination with other professional scientific organizations such as the American Physical Society (APS), the American Geophysical Union (AGU), etc. assemble a mechanism (perhaps in the initial form of a Wiki) which can be organized to collect resources from members who have spent time developing them. This wiki should be available to the general public as read-only, with additions and updates limited to a professional set of contributors and editors.

Just some of the advantages of collecting these resources:

- The capability of subjecting rebuttals of bad science to a level of review usually reserved for the peer-reviewed scientific literature. There are a number of flawed rebuttals floating around in the literature, and this mechanism enables bad rebuttal arguments to be identified and eliminated, or at least tagged as lacking.

- For the general public, the repository can be a one-stop source of more reliable information on bad claims often encountered on the internet. This is valuable for the informal education environment.

- For the educator, the repository can be a resource providing out-of-the-box ideas for lesson plans. There are a number of pseudo-science claims that can be addressed at the level of introductory physics classes so it can provide a reservoir of failed hypotheses for demonstrating how science works. Such exercises can be incorporated into an education resource branch of the repository.

- Old pseudo-science claims are constantly resurfacing under new labels. An archive collecting this information can facilitate identifying and addressing resurrected claims, saving time and effort.

Finally, it is well understood that these types of rebuttals, even good quality content, rarely deter the 'True Believer' of a claim, but that is not the primary audience. Most of us approach this problem with the understanding that the REAL audience of the rebuttal is the curious and interested third party that follows the conversation and really doesn't know the facts. THEY are the primary audience for this content, and the key to limiting the influence of pseudo-science in a modern society.

While there is a considerable amount of effort required to organize and coordinate such a project, some of it is already being done by volunteers. The major effort may be maintaining a suitable web site wiki (with perhaps some code modifications to better support educational resources) and developing a professional review process. The important part is to collect as much of the content available as possible into a form that can be more easily propagated to future generations and to improve science education.

Thanks for your attention,

William Thomas Bridgman, Ph.D
Physics & Astronomy

Resources
* TalkOrigins.org

* Bad Astronomy. http://BadAstronomy.com
* Exposing PseudoAstronomy. https://pseudoastro.wordpress.com/
* Crank Astronomy. https://crankastronomy.org/, https://dealingwithcreationisminastronomy.blogspot.com/
* Crank Astronomy as a Teaching Tool? http://adsabs.harvard.edu/abs/2010AAS...21546807B
* Crank Astronomy as a Teaching Tool. II. http://adsabs.harvard.edu/abs/2014AAS...22345105B
* AAAS: Perceptions: Science and Religious Communities. http://www.aaas.org/report/perceptions-science-and-religious-communities
* AAAS: Dialog on Science, Ethics and Religion. http://www.aaas.org/DoSER

Building an Inclusive AAS - The Critical Role of Diversity and Inclusion Training for AAS Council and Astronomy Leadership

Brinkworth, C. S.[1]; Byrd Skaer, A. M. [2]; Prescod-Weinstein, C[3];, Teske, J.[4]; Tuttle S.[5]

[1]National Center for Atmospheric Research (NCAR), Boulder, CO; [2]Cornell University, Ithaca, NY; [3]Department of Physics, University of Washington, Seattle, WA; [4]Carnegie Institution for Science, Washington DC; [5]Department of Astronomy, University of Washington, Seattle, WA

Diversity, equity and inclusion are the science leadership issues of our time. As our nation and the field of astronomy grow more diverse, we find ourselves in a position of enormous potential and opportunity: a multitude of studies show how groups of diverse individuals with differing viewpoints outperform homogenous groups to find solutions that are more innovative, creative, and responsive to complex problems, and promote higher-order thinking amongst the group (Antonio et al, 2004; Page, 2007; Sommers, 2007). Research specifically into publications also shows that diverse author groups publish in higher quality journals and receive higher citation rates (Freeman & Huang, 2014). As we welcome more diverse individuals into astronomy, we therefore find ourselves in a position of potential never before seen in the history of science, with the best minds and most diverse perspectives our field has ever seen.

Despite this enormous growing potential, and the proven power of diversity, the demographics of our field are not keeping pace with the changing demographics of the nation. According to the United States Census, in July 2015 13.3% of Americans identified as Black or African American alone, 17.6% identified as Hispanic or Latino alone, and 1.2% identified as American Indian or Alaska Native alone; 2.6% of citizens identified as two or more races. The Census Bureau also predicts that by 2044, whites will no longer be a racial majority in the United States (Colby & Ortman, 2015). Right now, only 2.1% of astronomers identify as Black or African-American and 3.2% as Hispanic, Latina/o, or of Spanish origin and extremely few are Native or indigenous (Ivie et al., 2014). Disappointingly, these numbers for Physics and Astronomy have remained essentially constant between 2004 and 2012. This underrepresentation is most acute in leadership roles and on the key committees that shape the future of our field. When considering those with multiple minority identities, the level of underrepresentation is compounded: in 2012, there were fewer than 75 faculty members in Physics or Astronomy in the United States who are both female and African-American or Hispanic (Ivie et al., 2014).

Much effort has been put into increasing the pipeline of underrepresented students into the sciences, but there is significant evidence to suggest that many minoritized students enter the STEM fields and then drop out before graduation. We can compare the number of freshmen in 2008 who reported an intent to major in STEM to the actual number of STEM degrees awarded in 2012 (Table 1; National Science Foundation, 2015; Brinkworth, 2016) and we find that there are huge disparities between graduation rates of White and Asian males compared to minoritized groups. There are many reasons that students drop out of STEM, including mismatches between interest and choice of degree, as well as financial issues (Seymour & Hewitt, 1997), but there is a wealth of research to suggest that these disparities in graduation rates across race and gender are largely due to institutional barriers and "chilly" or "hostile" climates that underrepresented groups experience in STEM fields. Research also suggests that work to remove those barriers and create more welcoming climates could dramatically increase retention rates (Seymour Hewitt, 1997; Yosso et al. 2009; Cech & Waidzunas, 2011; Fouad et al. 2012).

Table 1: Percentage of freshman intending to major in STEM in 2008, who received STEM degrees in 2012. Source: National Science Foundation, 2015; Brinkworth, 2016

	All	**Male**	**Female**
All	25.3	27.8	23.0
White	28.4	31.1	25.9
Asian/Pacific Islander	31.2	32.1	31.9
Black	14.0	16.3	12.8
Hispanic	16.9	17.1	16.3
American Indian/Alaska Native	16.1	17.9	15.6

There is a strong temptation to not discuss issues of race, gender identity, sexual orientation, and ableness in science. Many practitioners are uncomfortable with these topics, and believe that discussions around identity are irrelevant in a data-driven field like astronomy, where the scientific ideal is a meritocracy. However, astronomy has an existing culture, driven by "norms" that were established when our field was far less diverse. We continue to expect students, staff and faculty from all backgrounds to assimilate to the existing culture, rather than adapting that culture to become fully inclusive (Bell et al. 2009; Lee, 2015). This creates a heavy burden for those who are not part of that existing culture: Seymour & Hewitt (1997) found evidence that retention of minoritized groups in STEM is unrelated to their aptitude, but highly dependent on their ability to navigate the difficult social aspects of the fields. In a study of gender experiences in workplaces, Eisenhart & Finkel (1998) found that this cultural streamlining towards the dominant group can be invisible to all groups: both men and women in the study reported equal treatment, despite the researchers' objective observations of inequality in the workplace in favor of the male students and employees. Johnson (2007) found that a belief in "colourblind" and "gender-blind" meritocracy can negatively affect non-white, non-male students, reporting that:

> "*This match between Whiteness, maleness, and the characteristics needed for success in science was hidden in this setting by the silence about race, ethnicity, and gender, which was in turn hidden by the rhetoric of meritocracy. This silence prevented students and professors from seeing how ethnic, racial, and gendered dynamics helped determine which students found it easier to thrive.*"

Far from ensuring an equal, meritocratic workplace for all, a refusal to discuss social aspects of the STEM culture can be extremely stressful to underrepresented students, who are already being required to do extensive emotional work to navigate these unwelcoming climates (e.g. Seymour & Hewitt, 1997; Yosso et al, 2009; Fouad et al. 2012). In many cases, the silence leads to worse academic and mental and physical health outcomes for those we should be nurturing and celebrating as they start their science careers (Meyer, 1995; Meyer, 2003; Huebner & Davis, 2007; Nadal et al. 2011; Bockting et al. 2013).

Likewise, a refusal to discuss how discrimination in classrooms and the workplace impact specific groups of underrepresented minorities results in further amplifying the physical, emotional, academic and professional harm done to individuals within that specific group. Notably, the pervasive and uniquely targeted violence against African Americans has become highly visible over the last five years. For this reason, it is critical that the leaders of our field explicitly and openly recognize that Black students, staff, and faculty have faced and continue to face unparalleled threats to their ability to succeed fully in their careers due to systemic anti-Black racism that occurs both within astronomy departments and the outside world. This reality is reflected in the data and research, as discussed above; from hostile working and learning environments to outright threats to bodily integrity, Black members of our field face disproportionate barriers to their achievement and success. Any efforts to create a more creative, productive, and equitable field must open its eyes to the blight of anti-Black racism still prevalent today. The rallying cry that “Black Lives Matter” provides AAS with an opportunity to join a growing popular movement to support Black Americans, including those who are astronomers.

Likewise, it has become unavoidably evident in 2016 that Native American nations are confronting forces of marginalization that they uniquely face, such as transgressions of their right to self-determination on lands that are still recognized as sacred. This issue of indigenous self-determination has arisen for example in the debate about the Thirty Meter Telescope, in tandem with more basic questions of what language is appropriate when describing Native Hawaiians. Moreover, Native American and Pacific Islander communities face high rates of poverty, incarceration, and violence at the hands of the police. This impacts the ability of indigenous children to be positively affected by diversity and outreach programming as well as the ability of those who are already scientists or training to become scientists to successfully pursue their professional work. How we as a professional society respond to diverse viewpoints on these concerns impacts how welcome Native American and Pacific Islander students and scientists feel in the astronomy community.

In tandem, it is especially important to recognize that transgender people, especially those who are Black, Native American, and Hispanic/Latinx, are at heightened risk for verbal abuse and violence both within the workplace and in their everyday private lives. The majority of anti-LGBTQ violence in the United States is inflicted on transgender people, with Black trans women facing some of the highest per capita murder rates in the country (NCAVP, 2016). Additionally, trans people of color are regularly criminalized for engaging in activities that are necessary for their survival. Until we can confront these realities, along with the high rates of suicide of transgender youth and adults, it will be difficult to ensure that transgender people are able to participate in astronomy. Importantly, a study released this year of LGBTQ physicists and physics students by the American Physical Society found that transgender people experienced the highest rates of exclusionary behavior in the LGBTQ community and were especially at risk for leaving the field because they had witnessed discrimination (Atherton et al., 2016).

We further recognize that in the coming years how immigration reform, bilingual education, and a host of other issues are addressed on the political stage will have a particularly strong impact on the participation of Hispanics/Latinxs in science, including astronomy. It is critical that the American Astronomical Society pro-actively engage on these issues in a way that promotes the interests and opportunities of future and current members who are affected by them. Importantly, Hispanic/Latinx people also face disproportionate rates of violence at the hands of police as well as incarceration, heightening the possibility that AAS members from this group are personally impacted by these conditions.

The creation of more diverse and inclusive environments is crucial if our field is to remain relevant, and support all members of our field in pursuing their passion and fulfilling their potential. All the data suggest that highly capable future scientists are being lost due to our failure to create warm and inclusive work environments for women, people of colour, LGBTQ people, people with disabilities, and those at the intersection of these identities. Moreover, those who stay are being subjected to non-inclusive workplace environments that cause physical and mental health problems and prevent them from reaching their full potential. As it stands, our workplaces are inadvertently hindering scientific research and standing in the way of the scientific meritocracy that we are all trying to create.

This crisis in the sciences has already been acknowledged by many different groups, including by the NSF, which is pouring $75M into new diversity initiatives; by the media, who have reported extensively on sexual harassment issues in our field; by individuals in astronomy, who have been raising these issues for decades, pushing for more inclusive policies, and organizing conferences to address inclusion in astronomy; and eventually by the AAS itself. Our field requires strong, knowledgeable, and courageous leadership to immediately implement effective solutions and programs that will support both a culture shift in individual departments and the field as a whole, and also increase the representation of underrepresented minorities among both students and faculty.

In order to know how to best support our minoritized colleagues, we need to have a better understanding of what they are experiencing on a daily basis, in both our workplaces and in society. The impacts of racism, sexism, ableism, and homophobia do not simply vanish when minoritized students, staff, and faculty enter astronomy classrooms or offices. In many cases, the interactions with our colleagues can exacerbate the harmful effects of these forms of bigotry (e.g. Cech & Waidzunas, 2011). We frequently overestimate our ability to support our minoritized students and colleagues: Samuels (2014) found that educators almost unanimously believe that they are prepared for teaching students from different cultures, but virtually none had any experience or formal training with people from other cultures. In Samuels' words, "we don't know what we don't know." If we are serious about making change and creating inclusive and diverse workplaces that support every individual, we need to get better at first knowing what we don't know and then working to fill that gap in our knowledge and understanding. We need to realize that, for people with dominant identities (i.e., men, white people, heterosexual, cissexed and cisgendered people, people who are temporarily abled), our formal education fails to educate us about the experiences of those with non-dominant identities and therefore fails to prepare us for supporting our colleagues. Our hubris is doing active damage to our minoritized students and colleagues.

One of the first steps in rectifying these discriminatory working and learning environments is to ensure that everyone in a leadership role receives diversity and inclusion training to help them understand common issues experienced by minoritized people, and to equip our leaders with the knowledge of how to further their familiarity and comprehension of these experiences (Williams, 2013). All members of the AAS Council and leadership, the heads of astronomy departments, and faculty leading in graduate selection and faculty search committees should receive both an initial, comprehensive equity and inclusion training, and also continuing education and workshops. This training should include active engagement with the latest academic research on the idea and limits of "objectivity" (Harding, 2015).

It is an unacceptable and unscientific stance to accept the status quo as the most effective way of furthering the field of astronomy. In accepting the available data and research, we put ourselves in a position to influence and encourage more equitable representation in our field. Our work on issues of diversity must be driven by best practices and research from both the academic disciplines that have studied these issues, and also from individuals and groups with demonstrated expertise in addressing these concerns. To address the pervasive inequity and bias in our community, we must recognize that most of us are amateurs in the field of diversity and equity research. Seeking out and supporting necessary training is a first step to understanding the crisis within our community. To truly make a difference, this step must be followed by active engagement with experts and those underrepresented minority members of our field to create and implement real solutions.

Acknowledgements

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Diversity and Education: They Are Linked!
White Paper
Gina Brissenden

Improving diversity, equity, inclusion, and education within our astronomy community has been increasingly important to the AAS leadership and membership. I look to the types of AAS Committees, meeting workshops, posters, talks, etc. as partial evidence of this.

However, over the past few years when the leadership of the AAS brings together groups of stakeholders to discuss these issues, included are usually members of the the AAS Committees on the Status of Women, Minorities, Employment, etc., while members of the AAS Astronomy Education Board are not.

This lack of collaboration brings me to believe that we, as a Society, still do not understand the full effects of the choices we make in classroom instruction and climate.

Our leadership and our membership should take to heart the following:

> The way we teach has a tremendous amount to do with whether people persist (or don't) and are successful (or not) in pursuing STEM degrees (including astronomy). In particular, our most common way of teaching (relying predominantly on lecture) discourages and disenfranchise women, minorities, people from lower socioeconomic backgrounds, and people with disabilities—even when they are academically successful in their STEM degree programs.

Below are a few references related to this. I know some of them are somewhat old, but they are just as relevant today as when they were published.

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To: AAS Education Task Force

From: Dave Bruning
Assoc. Prof (retired)
Physics
Univ. of Wisconsin-Parkside

Date: 11 May 2016

Assessment of Educational Impact

Most EPO and educational assessments are very short-term and do not indicate what long-term learning or impact may have occurred. While studying pre- and post-activity gains in learning are important, most research does not even study semester long impact much less 1-year, 3-year or longer impacts.

While developing activities that seem to enable more students to understand concepts and to better prepare them for immediate exams has merit, that also reinforces to students that they study for a grade rather than longer lasting effects and deeper learning.

As a society, we should insist that future research into learning and EPO impact look at longitudinal effects. Using surveys at the end of one class or one outreach event should not be sufficient as people often rate immediate experiences as high but learning fatigue will settle in after several weeks or months; it is important to see whether learning or attitudinal changes are sustained into the future. It is hard and more expensive to follow-up students at later stages and to see whether attitudes and learning have been affected by educational reform and EPO efforts. But without longitudinal studies, all research into short-term modifications results in largely “feel good” efforts that does little to transform students into more independent scholars outside of the immediate class or the given EPO experience.

We seek to create transformative experiences so we should obtain data on whether the efforts we provide to students and the public really perform on lifetime scales and not only over a period of weeks or months. Early astronomy education research took the first steps in creating better learning and teaching methodologies. For the field to mature, we need to take the next step.

Physics education research has the advantage that they can track students over several years of a major and potentially into graduate school. However, most astronomy education research and EPO efforts deal with non-majors and non-scientists. Thus we need to implement other methods to determine long-term effects.

May 12, 2016

To: American Astronomical Society Education Task Force

From: Robert Buchheim (Bob@RKBuchheim.org)

Subject: AAS should embrace the Small-Telescope, Non-Traditional Research Community

Recommended Initiative: AAS should encourage data collection and research conducted by non-professional astronomers, and facilitate their participation in AAS and Division meetings.

Gaps in current activities: Ongoing activities (by AAS, ASP, etc.) do a fine job of: providing lectures aimed at public and student audiences; pointing to student enrichment activities for budding astronomers; supporting local science fairs; and providing resources for instructors. However these resources and activities are almost entirely based on archival or teacher-provided data, and are tailored to yield a desired learning objective. They are similar to the canned experiments done in chemistry class, where the 'correct' outcome is well known. Science fairs generally mandate that projects must follow the "scientific method" (hypothesis testing based on controlled experiments). It is difficult and often artificial to cast astronomy projects into this paradigm.

On the other hand, people using very small telescopes (backyard-scale and college-observatory-scale) are gathering useful data and conducting meaningful research. Examples include astrometry of visual doubles, photometry of variable stars, time-series and long-term spectroscopic monitoring of emission stars and eruptive variables, exo-planet transit timing. The *Center for Backyard Astrophysics* (photometric monitoring of cataclysmic variables) and the *BeSS* initiative (long-term spectroscopic monitoring of Be stars) are good examples of the science that can be facilitated by the community of non-professional researchers.

Opportunity: The community of small-telescope scientists engaged in these research activities (epitomized by the AAVSO and the SAS), extends from motivated high school students to undergrads to serious and well-equipped non-professional ("amateur") astronomers.

These people self-fund their equipment and software, because they see the science return from their investment; but the high cost of membership and participating in AAS and Division meetings is an impediment to them. Nevertheless, AAS can benefit from their passion, results, and capabilities; and they can benefit from being part of the AAS community.

I recommend that AAS consider taking steps to embrace these non-professional researchers into the AAS community. Specifically:

- Encourage the submission, acceptance, and display of Poster Papers by these non-traditional researchers at AAS and Division meetings.
- Create a mechanism whereby these non-traditional researchers, specifically non-members of AAS, can submit abstracts for Posters (perhaps by creating a special subject category).
- Facilitate participation in the meetings by these non-traditional researchers, by creating a no-cost Registration for them (probably restricted to people with accepted Posters and – for minors – their accompanying teacher or parent).

Organizations such as AAVSO and SAS can probably be counted on to help publicize these initiatives and encourage their members to take advantage of them.

Embracing these non-traditional researchers into the AAS community resonates with the AAS mission to "train, mentor and support the next generation of astronomers"; but it might also be synergistic with other initiatives.

My anecdotal experience as mentor to high school and undergrad researchers is that this group is more diverse – in terms of both gender and race/ethnicity – than most professional scientific organizations. Plus, at the high school and undergraduate level it is still practical to divert a student's educational goals toward science, math, or engineering. Astronomy provides a universally stimulating "hook" onto this path.

The adult (non-professional) small-telescope scientists are active and effective at both (a) conducting research and data-gathering, and (b) engaging with the public. They can be a powerful asset for AAS initiatives for education and public outreach, and as examples of practical scientific literacy.

Exposure to successful small-telescope non-professional research presented at AAS meetings may trigger collaborations with non-traditional researchers, to the advantage of both communities. AAS members may find these non-professional research activities to be meritorious examples that can replicated on their own campuses.

Double star astrometry; time series photometry of exoplanet transits, eclipsing binaries, and intrinsically variable stars; asteroid lightcurves; and spectroscopic monitoring of variable stars, can all be effectively done with small telescopes.

Invitation: A Meeting-in-a-Meeting on *Small Telescope Communities of Practice* has been approved for the AASsummer 2016 meeting. I encourage a representative of the Working Group to join us during that meeting.

Sustaining educational and public outreach programs in astronomy

Will Clarkson[1], Don Bord[1], Carrie Swift[1], Eric J. Rasmussen[1], Dave Matzke[1],
Steve Murrell[2], Mike LoPresto[2],
Timothy Campbell[3], Robert Clubb[3], Dennis Salliotte[3]

[1]University of Michigan-Dearborn, 4901 Evergreen Road, Dearborn, MI 48128
[2]Henry Ford College, 5101 Evergreen Rd, Dearborn, MI 48128
[3]The Ford Amateur Astronomy Club: http://www.fordastronomyclub.com/index.html

Abstract: We advocate meaningful support of sustained education-outreach partnerships between regional metropolitan undergraduate institutions and astronomical clubs and societies. We present our experience as an example, in which we have grown a partnership between the University of Michigan-Dearborn (hereafter UM-D, a 4-year primarily undergraduate institution or PUI), Henry Ford College (hereafter HFC, a 2-year undergraduate college), and maintained a strong collaboration with the Ford Amateur Astronomy Club (FAAC), which is highly active in the Detroit Metropolitan Area. By allowing each organization to play to its strengths, we have developed a continuum of education-outreach efforts at all levels, with connecting tissue between the previously disparate efforts. To-date, faculty and staff effort on these initiatives has been nearly entirely voluntary and somewhat ad-hoc. Here we suggest an initiative to sustain the continuum of education-outreach for the long-term. There are two levels to the suggested initiative. Firstly, partner institutions should dedicate at least half an FTE of faculty or staff effort specifically to education and outreach development. Secondly, professional societies like the AAS now have a great opportunity to support the education-outreach continuum at a national level, by facilitating communication between institutions and clubs that are considering a long-term partnership, by acting as a central resource for such partnerships, and possibly by convening or sponsoring events such as professional meetings among the metropolitan educational community.

Motivation: Regional institutions[1] are important economic drivers of the communities in which they reside. With a large regional intake, and (usually) a high proportion of graduates remaining in the geographical area, regional higher-educational institutions are in many areas the face of higher education in the US. Astronomy outreach in particular holds a special place in deepening the community benefits of higher education. For example, at the K-12 level, education/outreach efforts help to change school student preconceptions of the scientist as the “other,” and aiding the realization that college is a possibility. Interaction with higher-education students (and faculty) from the same community as these school students provides a success example in science by people like themselves, thus metropolitan regional institutions are particularly effective at this kind of community involvement. Secondly, education/outreach efforts help citizens to exercise their sense of ownership of the public higher education institutions that serve their community, thus maintaining the community-academia link. Importantly, this includes community members seeing the institution as a possible educational destination, which might not have previously been the case. At an individual level, should a participant pursue astronomy as a course of study, they will learn skills that will directly benefit them in the job market (such as data analysis skills or the ability to plan, conduct, and communicate experimental investigation).

A continuum of involvement thus exists, from occasional participation in (or awareness of) public outreach events, through to an individual setting themselves up for a career in research. Many metropolitan areas offer all the pieces along this path, and in nearly all cases the connecting tissue is maintained by volunteer personnel, contributing effort well beyond that for which they are being compensated. We propose a specific initiative to ensure the continuum of effort is formalized and sustained.

Background: As an example, we present three institutions within the Detroit Metropolitan Area which have operated together under varying degrees of partnership: a 4-year PUI (UM-D), a 2-year college (HFC), and an amatuer astronomy

[1] Here we define “regional institutions” as primarily undergraduate higher education institutions, whether 4-year or 2-year, for whom a majority of incoming freshmen are within driving distance of the institution.

club (FAAC). Recognizing the degree to which the two institutions complement each other, UM-D and HFC entered into a formalized partnership [1], including the use by students of each others' Astronomical facilities, and the development of educational materials using them. Here follow some relevant characteristics of the three organizations:

- UM-D offers an Astronomy minor as well as lower-level introductory courses, and a small program (~8-10 students) of undergraduate Astronomy research;
- HFC offers highly innovative educational programs, including the development of an Astrobiology diagnostic test analogous to CAER's ACT used in large intro-astronomy courses [2,3];
- Many HFC students will transfer to UM-D to complete their studies
- UM-D operates a campus observatory, with an 0.4m telescope and four smaller telescopes;
- HFC operates a planetarium with 38 seats, which is used in undergraduate education, K-12 outreach, and regularly-scheduled free public programs. It is one of only two planetaria in the area that does not charge for shows. For example, FAAC typically holds 6-7 public planetarium shows *per month* with the HFC planetarium.
- The Ford Amatuer Astronomy Club is prominent in the community with approximately 120 members and offering monthly lecture events, monthly public outreach observing events, and K-12 outreach events each year.
- Both HFC and UM-D have formalized commitment to the Metropolitan Area at high administrative levels see for example the UM-D Mission statement[2] and the HFC Mission statement[2].
- The goal of FAAC is to "encourage the study of Astronomy, math, the sciences, and related subjects for the benefit of its members and the general public" (e.g. FAAC homepage[2]).

Working together, our three organizations have had substantial impact both within and outside academia. UM-D, HFC and FAAC members together run an informal program of visits by K-12 students from the area, which typically impact large numbers of schoolchildren per year (of order a thousand per year at the planetarium, of order a few hundred per year at the UM-D Observatory). This allows each organization to play to its strengths: for example, most fifth-grade students in the Dearborn area visit the HFC planetarium, UM-D typically hosts about five hundred K-12 students per year in groups of about two dozen, and finally the continuous efforts of FAAC which are conducted year round. One prominent example is the Astronomy at the Beach event, which FAAC co-organizes through its membership in the GLAAC (the Great Lakes Association of Astronomy Clubs), which typically has about 4500 visitors.

The challenge: Faculty, staff, and club members traditionally provide these services on a voluntary basis. The effort is substantial [4], including (but not limited to): creation and maintenance of a web presence; administrative effort regarding publicity for events and real-time response to changing weather conditions; correspondence with a large number of individuals and organizations (e.g. local schools); development and maintenance of the facilities used (e.g. the observatory). This leads to at least three important obstacles to maintaining *sustained* involvement:

1. *Time & Personnel:* Sheer time pressure makes maintenance of a program involvement challenging when the effort is purely voluntary. For example, at UM-D the typical semester load is 3 courses per term for full-time faculty, 4 per term for lecturers, leaving little time for extracurricular activities.
2. *Innovation, not just maintenance:* Finding the time to properly develop innovations can thus be challenging. A 0.25 FTE involvement (for example to run and maintain a planetarium) tends in practice not to allow much time to develop innovations.
3. *Mission centricity:* Maintaining continuity can be difficult if the individual maintaining an institution's community education efforts is unavailable (e.g. on medical leave or long term research travel), the program could be compromised. Recognition of education/outreach efforts as a core part of the institutional mission, would also help insulate community involvement from short-term administrative fluctuation at the institutional level.

Meeting the challenge: We propose a program to institutionally protect community outreach programs by supporting the individuals who put so much time and effort into it. Specific initiatives:

[2] Links: http://umdearborn.edu/about/mission-vision ; https://www.hfcc.edu/about-us/mission ; http://www.fordastronomyclub.com/index.html

<u>*Educational institution:*</u>

1. At least 0.5 FTE support per institution should be committed to an individual whose formal tasks would be to maintain the resource used (e.g. observatory or planetarium), to set up and co-ordinate E/PO events, and to maintain relationships with the community;

2. Outreach efforts should be explicitly recognized as a service category in Promotion and Tenure considerations. For example, creating and conducting some number of community outreach events per semester could be counted equivalently to membership in a single campuswide committee;

3. A long-term community engagement program should be supported, with the form chosen to best-match the partner institution. Example forms might be:
    a. A guest speaker program, where (for example) astronomical society members would host public viewing at the campus observatory, or present a planetarium show;
    b. Establishment of a seminar course for undergraduates, focusing on public understanding of science; in which part of the course requirements is participating in public or K-12 outreach activities;
    c. Internships or co-ops (as a practicum for education students), in which students develop and/or present a K-12 outreach event, or develop new materials for planetarium events;
    d. An events program at the intersection of the amateur Astronomy community and the instructional community. In many cases these may already be in-place (for example UM-D and HFC's involvement with Astronomy at the Beach).

<u>*Professional Society such as the American Astronomical Society (AAS):*</u>

1. We believe that similar efforts and partnerships may be underway at other institutions, although as yet we have not been able to dedicate time to verify this. Professional societies such as the AAS should use their capabilities to gather such data on a national scale, to learn what education/outreach/community partnerships already exist;

2. A substantial amount of effort duplication is likely, since many institutions have some level of community outreach as a component of their core mission. A society like the AAS can provide a repository of knowledge and initiatives in order for the various collaborations to learn from each other's experiences;

3. Convening or sponsoring professional meetings with emphasis on the education/outreach interface.

Summary: Using the UM-D + HFC + FAAC collaboration as an example, we argue that co-operative education-outreach efforts between 4-year universities, 2-year colleges, and amateur astronomical clubs, provides important continuity in K-12 educational enhancement and community ownership of higher education and should be meaningfully supported. We identify initiatives that can be taken by partner institutions and professional societies like the AAS, to allow the education-outreach mission of the Astronomical community to be sustained in the long term.

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The AAS Astronomy Education Board's Role in Implementing Inclusive Astronomy Recommendations

Signatories:
Kim Coble (Chicago State University, AEB, CSMA, IA Organizer)
Jillian Bellovary (AMNH, CSMA)
Carolyn Brinkworth (NCAR, IA Organizer)
Adam Burgasser (UC San Diego, CSMA Chair, AAS Councilor-to-be, IA Organizer)
Kelly Holley-Bockelmann (Vanderbilt University, IA Organizer)
Jacqueline Faherty (Hubble Fellow, Carnegie Institution, CSMA)
Jedidah Isler (NSF Postdoctoral Fellow, Vanderbilt University, IA Organizer, NSBP)
Jessica Mink (CfA, CSWA, SGMA, IA Organizer)
Jorge Moreno (Cal Poly Pomona, CSMA Chair-elect)
Nick Murphy (CfA, WGAD, IA Organizer)
Dara Norman (NOAO, NSBP ASTRO, CSMA, IA Organizer, AAS Council)
Jane Rigby (GSFC, SGMA, IA Organizer)
Alex Rudolph (Cal Poly Pomona, AEB)
Keivan Stassun (Vanderbilt University, IA Organizer)

In June 2015, 160 astronomers, sociologists, policy makers and community leaders convened the first *Inclusive Astronomy* meeting at Vanderbilt University, in Nashville, TN.[1] The goal of this meeting was to discuss the issues affecting people of color, LGBTIQA* people, people with disabilities, women, people disenfranchised by their socio-economic status, and everyone who holds more than one of these underrepresented identities in the astronomical community. A set of recommendations[2] was produced covering four broad areas: removing barriers to access; creating inclusive environments; improving access to power, policy, and leadership; and establishing a community of inclusive practice.

Education can be a powerful vehicle for facilitating the growth of individuals and organizations in the areas of equity and inclusion. Furthermore, effective teaching and mentoring are a crucial part of creating inclusive climates in our institutions and in our classrooms. We propose the following types of partnerships and joint activities between the AEB and the "diversity" committees (CSMA, CSWA, SGMA, WGAD) of AAS. These activities will enable various stakeholders in the AAS membership to design and implement plans based on the IA recommendations at their institutions and in their classrooms:

- Hosting AAS workshops, forums, and other activities on issues related to equity, such as Title IX, Racism 101, allyship, etc.
- Hosting AAS workshops, forums, and other activities on implementing the IA recommendations for teaching (Appendix 2) and mentoring (Appendix 3).
- Plenary talks at AAS meetings that address issues of equity, inclusion, and effective teaching and mentoring.
- Including the AEB in conversations on equity and inclusion, for example by having AEB liason(s) within the "diversity" committees, and through participation in AAS diversity summits.

[1] **vu.edu/ia2015**
[2] **bit.ly/1JXIOzZ**

Appendix 1: Acronyms

- AEB: Astronomy Education Board
- IA: Inclusive Astronomy
- CSMA: Committee on the Status of Minorities in Astronomy
- CSWA: Committee on the Status of Women in Astronomy
- SGMA: Committee for Sexual-Orientation & Gender Minorities in Astronomy
- WGAD: Working Group on Accessibility and Disability
- NSBP: National Society of Black Physicists
- FAMOUS: Funds for Astronomical Meetings: Outreach to Underrepresented Scientists

Appendix 2: Recommendations for Adopting Active and Inclusive Learning Practices

The foundation of a successful career in Astronomy is educational opportunity. Students from minority/marginalized groups often experience classroom environments and dynamics differently than people from majority groups, and in ways that may reduce the effectiveness of teaching. Adopting research-validated practices and principles of inclusive design can eliminate barriers to learning and biases in assessment, making educational opportunity available to all.

1. Meet and exceed ADA requirements for accommodations in the classroom:
    a. Include explicit wording in syllabi outlining your commitment to extend reasonable accommodations to all students with disabilities, whether visible or invisible.
    b. Know what accommodations are permitted by your campus' Disabilities Office, and assure that students are receiving these accommodations in the classroom.
    c. Work with students who are in the process of obtaining accommodations to complete paperwork, and work with your campus's Disabilities Office to recognize and reduce barriers for students seeking accommodations.
    d. Make available testing environments free from distraction, and provide extra time (without judgment) for those who need it.
    e. Provide resources to faculty so that class notes and other teaching materials can be made available in multiple formats (audio, visual, captioned video, etc.).
    f. Provide students with spaces to move as needed; allow students free access to come in and out of class.
    g. If attendance is required, allow students a well-defined leeway in arrival/departure times, particularly for those with disabilities and when teaching on large campuses.
    h. Make sure class activities are fully accessible; if they are site-specific (e.g., observatory, planetarium), assure full access to disabled students; if they are at night, assure there are escorts available or on call.
2. Classroom participation and dynamics:
    a. Highlight the scientific contributions of a variety of astronomers, not just those who are white, male, able-bodied and heteronormative.
    b. Be aware of who you are calling on for questions and answers; avoid choosing one demographic group over another (e.g., only the men) or focusing on one section of the room (e.g., only the front). One way to achieve this is to wait until at least three students have raised their hands.

c. Be aware of and refrain from using racist, sexist, ableist, gender-discriminatory or homophobic language in the classroom; if such language is part of the instructional material (which should be rare in an Astronomy course), give students trigger warnings.
d. Pay attention to the classroom climate, and address discriminatory behavior promptly and respectfully; it is often helpful to have student representatives available for reporting.
e. Recognize that a "no-device" policy may inhibit the learning of some students; consider best practices such as separate seating areas in class for students who require devices versus students who find devices distracting.
f. Make clear policies on accommodation for students who have conflicts due to religious practice, medical treatment, family and/or personal emergencies.
g. Beware of organizing off-schedule activities that might exclude some students. For example, review sessions at unscheduled times might be difficult for students who have to work and/or commute via public transportation. (Commuting at odd times is particularly challenging for undocumented students, for whom obtaining a driver's license is extremely difficult in some states.)

3. Know what strengths, weaknesses, needs, and resources your students bring to the classroom, and adopt appropriate teaching and assessment strategies:
    a. Consider including diagnostic tests at the beginning of the course to identify what students' skills are coming into the course; design your teaching based on what the students know, not what you assume they should know.
    b. Diversifying your instruction techniques and resources can significantly improve inclusion; get to know your students and what works best for them.
    c. When implementing interactive teaching methods, make sure that students who do not want to participate (e.g., introverts, those with social phobias) are not forced to do so.
    d. Recognize that not all students have access to technology (e.g., their own laptops, calculators, clickers) and strive to eliminate technology barriers.
    e. Foster a growth mindset in your students.
4. Work to create a thriving, inclusive teaching environment by continually maintaining and improving your undergraduate program, which is necessary but not sufficient for attracting and retaining marginalized students:
    a. Provide opportunities (i.e. workshops, mentoring for teaching) and incentives (e.g. grants, recognition, etc.) for instructors, potential instructors, and teaching assistants to learn new pedagogical techniques and to adopt and develop research-based inclusive learning practices.
    b. Work with professional education researchers (e.g. university's center for learning, hiring astronomy education researchers) to evaluate and improve instruction in your department.
    c. Develop and support astronomy education research groups who investigate teaching and learning in astronomy through the lens of inclusivity and intersectionality.

Appendix 3: Recommendations for providing effective mentoring and networking opportunities.

Inclusive support of all astronomers requires robust networks of peers, mentors and advocates. Student-advisor, mentee-mentor and employee-employer relationships are among of the most important in a young scientist's career. However, these relationships can fail for a variety of reasons. Clear, non-stigmatized pathways for changing groups/advisors, having independent and senior advocates of students and postdocs, and developing community-based mentor networks are ways to prevent scientists from being derailed in their career progression. Additionally, realize that astronomers from small institutions or non-academic organizations may not have access to the same support network, and additional effort should be made to support them.

1. Establish a matrix of support for individual students and postdocs that does not rely solely on the advisor. This may be a formal network established by the department or institution, or an informal network endorsed by organizational leaders. Make sure there is both time and funding available for mentoring activities.
2. Follow the leads of HBCUs/MSIs/Community Colleges in establishing student-centered mentoring practices:
    a. Faculty and department leaders should consult with admissions and freshman advisors to identify and start advising potential astronomy/physics majors early on, especially underrepresented students.
    b. Provide support, mentorship, and research opportunities.
    c. Require faculty training on best practices in advising students and postdocs, including issues particular to underrepresented/LGBTIQA*/disabled students.
    d. Proactively engage and mentor transfer students, many of whom come from minority-serving institutions.
3. Establish a mentoring ladder to spans multiple career stages; e.g., graduate mentors of undergraduates, postdoc mentors of graduate students, junior faculty mentors of postdocs, senior faculty mentors of junior faculty, etc.
4. Establish identity support networks within and across STEM departments; and establish, support and make people aware of university-level resource centers for marginalized communities (e.g., Black Resource Center, Queer Resource Center, DREAMer Alliance etc.).
5. Increase networking opportunities for minorities and other disadvantaged students, and early career professionals within departments, at conferences, exchange programs, etc. Examples include the CSMA "Meet and Greet" reception at AAS meeting, travelling speaking grants (e.g., the NSBP/AAS Beth Brown Prize and the AAS FAMOUS travel grants).
6. Provide junior faculty with senior faculty mentors in the department who can guide them through the culture, responsibilities and expectations within the department (funding, tenure, students, navigating administration, etc.), and who can act as an advocate.
7. Support mid-career faculty/scientist mentoring and career coaching through national programs (e.g., Project Kaleidoscope, National Center for Faculty Development and Diversity).
8. Support astronomers from small institutions or non-academic organizations who may not have access to the same support network as those at larger institutions.

AAS-Sponsored Astronomy Education Partnerships with MSIs

Signatories:
K. Coble (Chicago State University)
K. Arvidsson (Schriener University)
D. Grin (NSF Postdoctoral Fellow)
J. Grube (Stevens Institute of Technology)
L. Trouille (Adler Planetarium)

Minority-serving institutions (MSIs) produce a large fraction of domestic minority STEM students and are excellent in teaching and mentoring students who are traditionally under-represented in STEM. However, many MSIs do not have undergraduate programs in astronomy or have limited offerings. Futhermore, astronomers who work at MSIs, like astronomers who work at other small colleges, often find themselves alone at their institutions. We feel that the AAS should support partnerships and networking opportunities between and among MSIs and other institutions in order to broaden the participation of minorities in astronomy and to familiarize astronomers from majority institutions with effective teaching methods that are inclusive of minority students' strengths.

Such programs should feature the following elements of meaningful partnerships:

- In a genuine exchange of pedagogical technique, approach, and course content, recognize the unique strengths, resources, insights, and expertise that MSI faculty bring to the table in serving a their students.
- Regular meetings throughout the academic year to build consistency and substantial relationships.
- AAS-supported venue for sharing instructional materials and resources that have been shown to be effective with minority learners.
- AAS- supported venue/workshops for networking among astronomers/physicists at MSIs.
- Support research on student learning that addresses the strengths as well as the needs of minority students.

We emphasize the value of creating and supporting meaningful, sustained partnerships between individuals and institutions over programs of limited duration or one-way exchanges that are paternalistic or condescending toward faculty and students at MSIs.

We base these recommendations on our experience teaching astronomy and physics at Chicago State University, an MSI on Chicago's South Side (85% African American, 70% female, average age 25). The MSI faculty member (Coble) partnered with postdocs at local research institutions (Northwestern University, Adler Planetarium, University of Chicago) who served as co-teachers, adjuncts, or guest lecturers. We met on a regular (weekly or bi-weekly) basis to discuss curriculum and implementation, reflecting on successes and areas for improvement. Excellent outcomes were achieved for for all involved: student evaluations were outstanding, the MSI faculty member got to network with other astronomers, and all postdocs secured permanent employment in astronomy.

White Paper:
Education and Public Outreach Activities Hosted and Supported by the Laboratory for Multiwavelength Astrophysics at the Rochester Institute of Technology

Compiled and edited by
Jennifer Connelly
Visiting Assistant Professor, RIT School of Physics and Astronomy (SoPA)
Joel Kastner
Professor, RIT Center for Imaging Science & SoPA
Director, RIT Laboratory for Multiwavelength Astrophysics

Contributors:
Jeyhan Kartaltepe, Michael Richmond, Andrew Robinson
Professors, RIT SoPA
Billy Vazquez
Lecturer, RIT SoPA
Triana Almeda, Kristina Punzi
Ph.D. Candidates, RIT Astrophysical Sciences & Technology Program

Summary

The Rochester Institute of Technology's Laboratory for Multiwavelength Astrophysics (LAMA) exists to foster the utilization and advancement of cutting-edge techniques in multiwavelength astrophysics by RIT faculty, research staff, and students, so as to improve human understanding of the origin and fate of the universe and its constituents. LAMA is one of three institute-designated Research Centers that are closely affiliated with RIT's Astrophysical Sciences and Technology (AST) Ph.D. program. Since its inception in 2011, LAMA has maintained active education and public outreach (EPO) programs involving both traditional outreach methods (e.g., Observatory open houses, K-12 classroom visits, etc.) and, more recently, novel approaches that tap into the potential of social media. This White Paper summarizes these various EPO efforts, some lessons learned, and some likely future directions.

Online and novel informal learning and outreach

LAMA faculty, led by Profs. Kartaltepe and Connelly, are actively engaged in online public outreach programs and have taken leading roles in conveying science results from large collaborative projects (e.g., CANDELS and COSMOS) that use facilities like the Hubble Space Telescope (HST) in addition to communicating broader topics/events in astronomy to the general public. Informal learning experiences now take place in a very broad range of settings and incorporate learning that is lifelong, life-wide (across a range of social settings), and life-deep (cultural values in the community and broader society), as detailed in the National Research Council's Learning Science in the Informal Environment report (NRC 2009, pp. 28-29). In the age of social media we have new opportunities to educate and engage audiences interested in astronomy, especially those not often reached through more traditional outreach efforts. These include opportunities in blogging, tweeting, gaming, and advertising of novel events, such as Astronomy on Tap as outlined below.

- Social media

The CANDELS blog (http://candels-collaboration.blogspot.com/) presents science snapshots, paper summaries, and insight into the lives of astronomers and has reached a vast audience (over 200,000 hits from all over the world). Both

CANDELS and COSMOS maintain active social media accounts on Twitter and Facebook and these have been steadily increasing in followers.

- Galaxy evolution mobile game app design concept

As part of a funded HST/EPO project, Prof. Kartaltepe is working to develop a mobile game app designed to bring the science of galaxy evolution to the general public in a fun and engaging way. People spend an enormous amount of time on their mobile devices playing games. Our goal is to use just a fraction of that time to communicate scientific knowledge. Previous astronomy-themed games have been very popular and have focused on things like solar system formation and exoplanets. However, there has not yet been a game that focuses on the big picture question of how our galaxy came to be and understanding the structure of our universe. The human drive to understand our origins extends far beyond our solar system and questions surrounding the distant universe can be some of the most fascinating. With this EPO project, we will address some of these deep questions by developing a mobile game where the game player explores the origin and evolution of different types of galaxies, including our own Milky Way.

Although this game is not specifically aimed at K-12 education, we are working to ensure that it meets National Science Education Standards, specifically content Standard D on "The Origin and Evolution of the Universe" for grades 9-12. This summer, an RIT undergraduate student (Physics and Computer Science double major) is working on some of the basic game design and development. Later this summer, a local high school student will also work on this project. Both of these students will learn about galaxy evolution science, but also gain skills in programming and app development.

- Astronomy on Tap

Over 150 Astronomy on Tap (AoT) events have been held in the last three years at bars and cafes all over the world. These audience-centric evenings include regular events in roughly 15 locations and several singular events. Each event features a few professional scientists, mostly professors, postdocs, and graduate students from RIT and nearby institutions, giving down-to-earth presentations of their research, an astronomy topic in the news, or of pop science that are approximately 15 minutes in length each. These talks are interspersed with music and trivia.

So far four AoT events have been held in Rochester, organized and emceed by Prof. Connelly (a non-tenure track faculty member at RIT), with nearly full house attendance of ~50 people at each event. Advertising is done utilizing Facebook and other online tools. A sign language interpreter is available upon request and the venue is accessible to those using mobility aids. Accessibility for these communities is a primary concern of the organizer and an area we feel is often neglected at traditional astronomy outreach/education events.

These events allow us to directly reach an audience that consider themselves life-long learners interested in science and/or astronomy, but that may not attend more traditional outreach events. Many attendees report that they read popular science articles and follow social media accounts hosted by astronomers and other science communicators and most are between the ages of 20 and 40. Connections between astronomers at different institutions are also a positive byproduct of AoT events. Organizations like the Rochester Museum and Science Center have begun to provide prizes, including tickets to planetarium shows. This has proven mutually beneficial and is tied to further connections as described below.

AoT events are free but donations are solicited in order to help cover costs. Equipment (portable screen, projector, etc.) is borrowed and the organizer, interpreter, and speakers do not receive remuneration. A buy-in or small grant(s) from academic institutions and/or the Society to cover equipment, venue, and other costs would allow for the continuation and growth of these novel and popular events. Already the organizer struggles to meet the demands of a growing audience.

This summer, Prof. Kartaltepe is helping with the organization of a special AoT event in Baltimore, MD, scheduled to coincide with the COSMOS collaboration meeting. Four speakers (including Prof. Kartaltepe) will be talking about HST, the COSMOS survey, and some of the exciting science results to come out of the survey. This is just one way that the collaboration that has benefited from public science funding can give back to the community and convey some information to the public about the kind of research they are helping to fund.

Community outreach organized by/within our institution

On-site events continue to be an essential part of engaging the Rochester community and spreading the word about contemporary astrophysics methodology and our understanding of the universe generally, and the ongoing research thrusts and discoveries of RIT faculty, staff, and students more specifically.

- Imagine RIT Festival

The Imagine RIT Innovation and Creativity Festival is a free annual event held on the campus of RIT. The purpose of the festival is to showcase the work and research conducted by RIT students and faculty, and get the public excited about science and technology. ~30,000 visitors experience the breadth and depth of RIT through interactive presentations, hands-on demonstrations, exhibitions, and research projects set up throughout campus. Since 2011, graduate students, post-docs and faculty in the AST graduate program have participated in the festival by showcasing their astronomy research in a fun, interactive and hands on way (e.g., Rapson et al. 2013, AAS Meeting #223, id.444.03). Exhibits are usually broadly focused on ongoing PhD research in the fields of stellar life cycles, galaxy evolution, and active galactic nuclei, and highlight graduate student use of observational facilities spanning the full electromagnetic spectrum. We have found that interactive games such as astro-trivia, and hands on activities such as building a scale model of the Hubble Space Telescope were the most exciting for visitors. Interactive pieces of the exhibit in general received the most attention, whereas posters and videos, despite their pictorial nature, were not as well received. The most popular piece of our exhibit each year has been solar observing with eclipse glasses and telescopes. Most visitors who observed the sun were left awe-struck and stated it was their first experience viewing an astronomical object through a telescope. On the basis of these "lessons learned", we continue to improve upon our exhibits by introducing new hands-on activities to engage the local public while presenting an overview of astronomy research at RIT. Our participation in the event is funded by the RIT College of Science and by the AST graduate program.

- Celebrate Science

LAMA faculty and students also take part in a yearly interactive science exhibition held during RIT Homecoming weekend. This smaller and more focused event allows for longer interaction with visitors and we have started to see the same faces returning and recalling past demonstrations.

- RIT Observatory Open Houses

RIT has a small observatory on campus with permanently mounted 12-inch and 14-inch telescopes, as well as many portable instruments. We offer 3-5 Open Houses each year, based on current events in the sky, to which all members of the Rochester community are invited. The number of visitors ranges from 20 to over 150 for eclipses and transits. These occasional exhibitions keep people in the area aware of the existence of our Observatory, but may have only small lasting effects.

We also host meetings for small groups: elementary school classes, Girl Scout and Boy Scout troops, and campus organizations. At these events, we have a chance to talk with individuals for more than a few minutes, and to tailor the experience to the interests of our guests. These may offer the visitors a better experience, but take more time and effort to arrange per visitor than the big Open Houses. Many guests these days want to take pictures of the Moon and planets through our telescopes, using their cellphones. Small brackets made specifically for mounting such devices on telescopes facilitate this brand of "do-it-yourself" astrophotography, which can serve as a particularly effective means to get visitors excited and even more curious about astronomical imaging.

Outreach with outside existing educational institutions

- Links with the Rochester Museum & Science Center

Astrophysics graduate students from RIT have forged a strong link with the local Strasenburgh Planetarium, which is a part of the Rochester Museum and Science Center. The planetarium, whose mission is to foster a deeper understanding and appreciation of the Universe and its contents, has been operational since 1968 and still uses the Carl Zeiss projector originally installed. So far two graduate students have become part-time employees at the planetarium in order to enhance their presenting skills as well as educate the public on the latest news in astronomy. They act as role models to the young who attend the shows. Also, their involvement aids in the promotion of the work being conducted at RIT and facilitates the content for new shows. With the assistance of RIT graduate students, Strasenburgh Planetarium star shows are frequently updated both to inform the public as to what is currently up in the night's sky and to provide up-to-date information on the latest discoveries in astronomy. For instance, we are currently showing a short video (created by the planetarium director) that explains the discovery of Gravitational Waves and the central role played by RIT's Center for Computational Relativity and Gravitation (http://ccrg.rit.edu/) in the analysis of this phenomenal discovery.

- Astronomy Section of the Rochester Academy of Sciences

The Rochester area has a particularly active amateur astronomy organization, the Astronomy Section of the Rochester Academy of Sciences (ASRAS). ASRAS has an impressive observatory about fifteen miles south of the city. They hold monthly indoor meetings, free and open to the public, and offer 2-3 night-time star parties each month. We (faculty and grad students) often make presentations at their indoor meetings. The audience is a good mix of experts and novices, all of whom enjoy asking questions and chatting informally.

ASRAS offers one of the best venues for outreach to the community -- because they are the community. Many of their members are teachers in local schools, so by working with them, we work indirectly with their students. A few of the members are dedicated to educational events themselves, especially those designed for elementary school students.

Training undergraduate & graduate astrophysics students in the 'art' of EPO

- Graduate student teaching

Astrophysics graduate students have increasingly become involved in teaching undergraduate introductory courses in astronomy and physics courses. Leading these courses provides essential training in college-level classroom instruction. Preparing and delivering lectures exposes the grad student to a new audience and to a different delivery method from the typical research-based oral presentations to which graduate students are exposed. Working in a workshop format presents an opportunity for the graduate student to develop student-instructor communication skills and to understand how best to convey basic concepts in math and physics.

Several astrophysics graduate students have designed and taught astronomy courses for the University of Rochester's summer *Rochester Scholars Pre-College Program*, which is offered to high school students. For example, during July 2014 and 2015, PhD student Triana Almeyda taught an introductory course, "The Infinite Wonders of Space", that she created and designed.

- Undergraduate student research programs and supervision

Via its discretionary funding and, more generally, the dedication of its participating faculty, research staff, and AST graduate students, LAMA maintains a strong undergraduate student research program. This undergraduate research program operates with a loose "top-down" structure, in which faculty supervise graduate students, and the grad students in turn take lead roles in supervising one or two undergraduates, with mentorship and assistance from the faculty.

The LAMA-supported undergraduate astrophysics research program is especially vigorous during summer, when the program operates in close association with the Center for Imaging Science (NSF-sponsored) Research Experience for Undergraduates (REU) program and other undergraduates working with AST Ph.D. students. Small working groups, organized around research themes and data analysis techniques, develop naturally during these intensive summer periods. Biweekly group meetings are held in which the undergraduate students, along with AST grad students and LAMA faculty and postdocs, give research status reports and share results with each other. These LAMA- and REU-supported summer student projects normally lead to student presentations at the RIT Summer Undergraduate Research Symposium. Some undergraduate students also present at the winter AAS meeting following their summer of research.

Briefing Memos

(email received from Kelle Cruz 6 May 2016)

Hi,

Here' s a quick and dirty White Paper for your consideration.

I would like the Education Task Force to consider the idea of the AAS providing "Briefing Memos" regarding current astronomical events to the membership (and alumni) in order to empower folks to be Astronomy Ambassadors. I envision the mailings to be one every 1-2 months and include recurring events (meteor showers, blood moons, eclipses, etc) as well as major events (e.g, LIGO announcement, major space mission events/landings/returns, etc.) Basically, anything astro-related that's likely to end up on the local news.

The vision, has outlined and discussed in the email thread below, is this:

The target audience is the busy-with-other-things-typical AAS member who wants to quickly add some material to their class, is asked by an acquaintance on the plane or at the bar about the event, or is asked to speak to the local newspaper or TV News. The idea is to give everyone an email at their fingertips that gives the low-down and a quick route to more educational material.

- 3-5 short, bulleted list of talking points aimed at the professional astronomer.
  e.g., what's a compact binary merger? facts and figures in various units.

- 1-2 bullets with a a public policy angle
  how was this funded? and which congressman should we thank/encourage people to vote for?

- a bulleted list of links to curated resources.
  e.g., LIGO info page, general GW info page, journal article

- direct links to curated graphics, illustrations, and animations.
e.g., relevant PhD Comics videos

---------- Forwarded message ----------
From: **Kelle Cruz** <kellecruz@gmail.com>
Date: Wed, Feb 10, 2016 at 9:56 PM
Subject: Re: Talking points memos
To: Kevin Marvel <kevin.marvel@aas.org>
Cc: Meg Urry <meg.urry@yale.edu>, "David J. Helfand" <djh@astro.columbia.edu>, jones@aas.org

That's great! I think the NOVA pieces are awesome and very close to what I'm suggesting with three key differences:

1) NOVA comes out very frequently, which is awesome! But what I'm suggesting is more like "NOVA BREAKING NEWS" that gets more widely disseminated than a typical post. I strongly think it should be an email blast to everyone. We want to get *all* the members to pay attention, not just the ones who already know about NOVA. (I bet less than 10% of the membership even knows about NOVA at this point…maybe this would be a great opportunity to market the site!)

2) Include POLICY talking points. Empower the membership to talk about funding avenues and budgets and what the tax payer dollar is buying in terms of science. Similar to the old ACTION ALERTS.

3) the typical NOVA's do not include many external links to other educational resources. For example, here are links which would be awesome to include in a LIGO piece:

- PhD Comic video about gravitational waves: http://www.phdcomics.com/comics.php?f=1853

- Universe Today: How GR wave detectors work: http://www.universetoday.com/127286/gravitational-wave-detectors-how-they-work/

- Nature: History and Commentary: http://www.nature.com/news/physics-wave-of-the-future-1.15561

Empower the membership to educate others about these breaking events. Make it *easy*. Make it clear that it's something that is expected of all AAS Members and that the AAS is here to support that effort. Most of us want to do this, we just don't have time to learn-all-the-things. Help us out a bit at times like this when the spotlight is on us and the visibility of our community and profession is so astronomically high.

Kelle

On Wed, Feb 10, 2016 at 9:34 PM, Kevin Marvel <kevin.marvel@aas.org> wrote:
Kelle,

There will be an AAS NOVA piece that will be released in parallel with the actual papers in PRL and ApJL.

Cheers.

Kev.

On Feb 10, 2016, at 9:33 PM, Kelle Cruz <kellecruz@gmail.com> wrote:

A briefing memo sent to all AAS members about the gravitational waves announcement tomorrow would be super helpful. It would greatly empower the entire membership to make the most of this groundbreaking event. If there's a time to do this just *one time* this year, I think this is likely it.

As a reminder, here's the vision:

The target audience is the busy-with-other-things-typical AAS member who wants to quickly add some material to their class, or who is asked by an acquaintance on the plane or at the bar about the event, or is asked to speak to the local newspaper or TV News. The idea is to give everyone an email at their fingertips that gives the the low-down and a quick route to more educational material.

- 3-5 short, bulleted list of talking points aimed at the professional astronomer.
  e.g., what's a compact binary merger? how was this funded and which

congressman should we thank?

- a bulleted list of links to curated resources.
  e.g., LIGO info page, general GW info page, journal article

- direct links to curated graphics, illustrations, and animations.

(It seems as though the Physics folks at Columbia are all over this. They have a big event scheduled for tmrw and have put together a mini-workshop for next weekend. I'd be happy to reach out to them to ask if they have someone who could help put this together.)

Kelle

On Nov 21, 2014, at 11:45 AM, Kelle Cruz <kellecruz@gmail.com> wrote:

Maybe Andrew Frankoi could be recruited to make the Briefing Memos? He's already doing something very similar with his own blog. Would you like me to reach out to him?

http://fraknoi.blogspot.com/

Kelle

On Wed, Nov 12, 2014 at 11:19 AM, Kelle Cruz <kellecruz@gmail.com> wrote:
A Briefing Memo, sent out yesterday, about the comet landing would have been awesome!

On Tuesday, October 21, 2014, Kelle Cruz <kellecruz@gmail.com> wrote:
I absolutely agree that starting with the AASMail is the way to go for the Briefing Memos. I just want to be clear that I think it would be *more* effective as its own mailing. My understanding is that the AAS web infrastructure has this capability (user managed subscription options) but that we are not ready to start using it yet.

I think a Committee on Outreach makes sense...I would slightly prefer the title be called Communication instead of Outreach. Much of what that committee could address falls under the heading of "in reach", or astronomers communicating better with other astronomers, and not just with the public. "Outreach" also, unfortunately, has a negative stigma as being something which hard-core scientists don't do. I think the committee would be even more powerful if not weighed down by that stigma.

I will respond to your other questions about the EC under separate heading.

Kelle

On Tue, Oct 21, 2014 at 1:45 PM, Urry, Meg <meg.urry@yale.edu> wrote:
Hi Kelle,
We've talked about this direct-message plan before and it has potential but for the purpose immediately at hand, starting with AASMail is the best way to go. We can do it now (as opposed to developing something new), and as a bonus, we should be able to gauge the level of uptake. Also, this fits in with conversations about your idea about a committee on outreach. Which in turn depends somewhat on revisiting the agenda of the education board, which has overlapping interests. So I'm sorry if this seems slow but I don't see any need to move faster on this when we already have a workable vehicle (AASMail). (Kevin, can we add the idea of a Committee on Outreach to the Council strategic planning discussion on Saturday?)
Many thanks for all the ideas and energy!
Cheers,
Meg

--
C. Megan Urry
Israel Munson Professor of Physics and Astronomy
Director, Yale Center for Astronomy & Astrophysics
President, American Astronomical Society
PO Box 208120 New Haven, CT 06520-8120
(office) JWG 460, 203-432-5997
(YCAA) JWG 454, 203-432-3392
(fax) 203-432-3824
meg.urry@yale.edu

The mission of the American Astronomical Society is to enhance and share humanity's scientific understanding of the universe.

From: Kelle Cruz <kellecruz@gmail.com>
Date: Monday, October 20, 2014 at 2:55 PM
To: Kevin Marvel <kevin.marvel@aas.org>
Cc: David Helfand <djh@astro.columbia.edu>, Meg Urry <meg.urry@yale.edu>
Subject: Re: Talking points memos

I really don't care too much about this particular comet-Mars event. I care much more about building the infrastructure to empower our membership to be astronomy ambassadors for future events.

Yes, I recognize this would be more work...which is why I asked about a committee. I think there are many members who would be interested in working on the various kinds of communication facilitated by the AAS, including actually writing the briefings. Committee could have regular members from the general community (not affiliated with a mission) and maybe folks from the JPL, NASA, ESA press/outreach offices. (The folks who know about the big events and are making the relevant visualizations.)

The rate at which I would envision the briefings to go out would be ~1 per month. The ones for meteor showers would be very similar every year but would just have updated date, time, and moon phase info. There could be one per year about the super moon, blue moon, etc.

The astronomy in the news ticker is cool, but very different than what I am suggesting. The briefing memo would be similar to a AAS written press release but would be aimed at the professional audience, include bullets instead of prose, and include a compilation of relevant resources from a variety of sources. It would *not* just be a link to one press release but rather include a list of links to multiple relevant press releases, articles, websites, twitter accounts, and hashtags.

Kelle

On Monday, October 20, 2014, Kevin Marvel <kevin.marvel@aas.org> wrote:
All,

We will look into letting people know about this event, which has been publicized for quite a while,
so I can only guess that everyone is too busy to read daily digests from media sources like S&T, probably
a good thing!

However, from a logistical point of view, to have an ongoing service that lets AAS members know about
'interesting' things going on or about to happen, and to do so in a comprehensive way, would require
additional people power than what we have now. Woe be it to the organization that forgets to publicize
one person's favorite 'neat' event vs. another person's.

Not an impossible task, but a challenge to providing such a new service.

Also, as David knows, we have an 'Astronomy in the News' ticker on the AAS home page and the Mars event
is currently the second item in the list. Rick curates this following some guidelines we have developed
in the past year or so. This is basically just a culling of media sources that Rick does each morning and
then updates as appropriate items come up. In the current case, a JPL press release sparked the link to
the detailed information about MRO studying the comet, which is just one of many missions gearing up to
look at the comet as it passes Mars.

Cheers!

Kev.

On Oct 20, 2014, at 12:52 AM, David J. Helfand <djh@astro.columbia.edu> wrote:

I know I would value this, as I was asked this weekend by a Quest parent about this and was clueless.

Cheers. david

On 10/19/14 5:47 PM, Urry, Meg wrote:
Hi Kelle,
I think quite a few members would value this – if perhaps not all. The most effective way to reach the most members would be to include a short item in the next AASMail, with a link to a posting about it. I'm cc'ing Kevin to ask whether this is something Rick should do – and I'm sure he'd welcome input about this, if you have something specific in mind.
Cheers,
Meg

--
C. Megan Urry
Israel Munson Professor of Physics and Astronomy
Director, Yale Center for Astronomy & Astrophysics
President, American Astronomical Society
PO Box 208120 New Haven, CT 06520-8120
(office) JWG 460, 203-432-5997
(YCAA) JWG 454, 203-432-3392
(fax) 203-432-3824
meg.urry@yale.edu

The mission of the American Astronomical Society is to enhance and share humanity's scientific understanding of the universe.

From: Kelle Cruz <kellecruz@gmail.com>
Date: Sunday, October 19, 2014 at 1:54 PM
To: Meg Urry <meg.urry@yale.edu>
Subject: Talking points memos

Wouldn't it be awesome if all AAS members were sent a briefing memo about the comet mars thing about to happen? It would include a 1 paragraph description, images, and links to the best resources.

I genuinely think this would be a valued member benefit and would significantly increase the membership's participation in informal outreach opportunities.

Kelle

--
kelle
(via iOS)

Professional Development, Education Research, and Meeting Costs

Noella Dcruz: White Paper (submitted via email text)

1. Professional Development – training in teaching methods

There is a need to train astronomers in learning about and implementing proven teaching strategies at least at the undergraduate level. A lot of the undergraduate students who take astronomy classes are non-science majors, and astronomers are not always aware of how best to teach students who are not science majors, hence the need for training. There are many excellent materials available at present. There are workshops that are held to train teachers too. These need to be continued.

In addition, there needs to be more done to make astronomers aware of the teaching methods and materials available in physics and astronomy that help astronomy and physics majors learn more effectively.

There also needs to be training in assessment methods, so that teachers can gauge how well they are implementing different teaching strategies. A number of institutions and accrediting agencies require assessment that goes beyond each class an instructor teaches, so having better assessment training can help with this.

2. Education Research

The AAS needs to be promoting education research, much like it promotes scientific research. I am glad to see that the AAS meeting organizers now recognizes education research on the same level as scientific research, and that the AAS allows members to present one research (scientific or education) and one education/outreach abstract at meetings.

I was very disappointed when the AAS decided to close down the Astronomy Education Review. I felt it was an indication that the society is not keen on education and education research. I ended up publishing an education research paper in a journal outside the US since there was no other option at the time.

I am not sure how the AAS should promote education research now that it is no longer supporting a journal. Since there is a new US journal for this small field, there is no need for the AAS to put develop another journal at present.

As I mentioned at #1, how to carry out appropriate assessment beyond quizzes, homework and exams is needed. Learning how to do this is not easy, and the AAS needs to ensure that astronomers and teachers feel comfortable with this, especially as institutions and accreditation agencies are requiring assessment of multiple sections of courses, of degree programs, etc. nowadays. This is one example of where education research is needed in higher education. Other areas of education research need to be promoted too. Perhaps partnering with the AAPT may help, and will certainly reduce duplication of effort.

3. Professional Development – cost of attending conferences, workshops.

The cost of attending meetings has gone up a lot over the years, which makes it difficult to attend AAS meetings and other conferences. I would have liked to attend the San Diego AAS, but the hotel cost was very high, so I decided against attending. If it is possible to offer the

FAMOUS grants more often or bring the meeting cost down in some way that would help a lot for those who have limited travel funds. I am not sure what suggestions to make, but it is important for teachers at all levels and outreach educators to be able to attend conferences and workshops, and there is not enough of travel funding available for this. Perhaps suggestions from the ASP and AAPT may help with this.

4. K-12 teacher training, bridging to college with NGSS
I feel the AAS could be more involved with K-12 teacher training now that there is more astronomy in the curriculum for school that are using the NGSS. I feel AAS needs to be involved with the transition of students who learn science with NGSS curriculum into high school and college i.e. the teachers in high school and college need to be aware of what preparation these students have and accordingly adjust to ensure that students are successful in high school and college courses. The AAS can partner with organizations like the AAPT and ASP in these efforts, so the efforts are not duplicated and the resources of the AAS are not strained.
It is possible that in the future similar efforts would be needed, so it would help if the AAS could play a continuing role in K-12 education.

5. There needs to be more awareness of careers in the K-12, community college and public outreach sectors in addition to jobs that involve research (both scientific and education).

Edna DeVore, Director of Education
SETI Institute

<u>Why foster and support education and outreach aimed at the public?</u>

> ***We live in a society exquisitely dependent on science and technology,***
> ***in which hardly anyone knows anything about science and technology.***
> …..Carl Sagan

The American Astronomical Society is a leading organization of professional scientists who share the excitement and thrill of discovery broadly. Beyond the professional publications, meetings and events, the AAS members foster the next generation of STEM professionals through education and training. Further, astronomy has wide public appeal, and AAS education and outreach activities motivate interest in science among young people who go on to pursue STEM careers.

What is the appeal? For the public, "astronomy" is everything beyond the Earth, and astronomers (in all the various disciplines) are explorers making the discoveries of the 21st century in space. Astronomers aim to better understand our place in the universe. They probe questions that intrigue us: Is there life elsewhere in the universe? Can we find life on Mars or moons of Jupiter and Saturn? Are there other worlds like Earth around distant stars? What is the future of our home planet? Will we travel through space to distant stars? What is the origin and fate of the Universe? And many more…

When we share our work with the public, we are also paying a dividend to the people who fund our research. Astronomy is an "impractical science" that produces knowledge and understanding of our universe. It doesn't invent the next vaccine, or engineer a bridge. To be sure, there are technical spinoffs from the development of astronomical tools, but the main product is knowledge that enhances human culture. Thus, the knowledge and enjoyment of astronomical discoveries and advances are the dividends we return to the taxpayers and donors who support our work.

<u>Education, Professional Development and Outreach (E/PD/O) at the SETI Institute:</u>

The SETI Institute is a private, nonprofit organization dedicated to scientific research, education and public outreach. The Institute comprises three centers: the Center for Education, the Carl Sagan Center for the Study of Life in the Universe, and the Center for Public Outreach. Founded in 1984, today the SETI Institute employs over 130 scientists, educators and support staff. More than half of our employees are women. We have a strong commitment to scientific research and to education, outreach, and training the next generation of scientists as explained in our mission statement:

> ***Our mission is to explore, understand, and explain the origin and nature of life in the universe, and to apply the knowledge gained to inspire and guide present and future generations. We have a passion for discovery, and for sharing knowledge as scientific ambassadors to the public, the press, and the government.***

<u>The key to our success is that our E/PD/O programs are based upon our scientists' interests and tie directly to their work. Our scientists share their work and involve students and the public through our E/PD/O programs.</u> The programs that we conduct reflect the interests of our scientists and educators, and are both funded and voluntary. Our E/PD/O work offers a model for how a scientific research organization conducts a broad and robust E/PD/O program. Briefly, these are the projects that we conduct:

Education and Professional Development:

- Research Experience for Undergraduates: internships with scientist-mentors now in 11th year with more than 140 student participants with the majority being women; underserved students recruited via partnerships with HSU campuses
- University courses: Institute scientists as visiting professors, part-time faculty
- Graduate students: scientists on PhD committees, and employ grad students on research projects and field expeditions
- Post-Docs: employment on research projects and field expeditions
- Textbooks: Shostak/Bennett and Backman/Seeds author the leading astrobiology and astronomy undergraduate textbooks (respectively) for general education
- High school science curricula and teacher PD institutes: "Voyages through Time" in 400+ schools nationally
- Classroom visits by Institute scientists and educators
- Research stations that involve students: Cameras for Allsky Meteor Surveillance, Haughton Mars Project, Atacama Desert and High Lakes projects, and others
- NASA Mission Education and Outreach: SOFIA, Kepler, MAVEN (historic)
- NASA SMD Education: national Girl Scout program, and Airborne Astronomy Ambassadors with SOFIA (current funded work)
- US and International Space Camp in collaboration with NASA: Spaceward Bound
- Advisors: planetarium programs and museum exhibits

Public Outreach and Public Affairs:

- Big Picture Science: SETI Institute's radio program: 100 + broadcast stations; 100,000+ downloads weekly
- SETI Institute Colloquium series: weekly science talks for the public; streamed and YouTube: 10th year; 2 million+ viewers
- Speakers at public events nationally and internationally, e.g., TED, TEDx, US Science and Engineering Festival, Bay Area Science Fair, science centers, planetaria, museums, etc.
- Osher Lifelong Learning: courses for senior citizens
- Scientists as Solar System Ambassadors (JPL) and Night Sky Network (JPL+ASP) Museum Alliance (JPL) volunteers
- Science at the Library events at local libraries
- Death Valley Centennial and Mars Fest: partnership with National Parks
- Articles for the general science interested public regularly published in Huffington Post, Space.com, and other online sites.
- Social media: Facebook (520k), Twitter (557k), Google+ (7.3m), LinkedIn (4k)
- Website: ~4k per week = ~1.5 m per year.
- Press releases, press conferences and hangouts
- 5 to 10 media interviews per month of our scientists.

Contact:

Edna DeVore, Director of Education
SETI Institute
189 Bernardo Ave. #200
Mountain View, CA 94043
edevore@seti.org
www.seti.org

How to Be a Better Professor to Your LGBT+ Students:
A White Paper to the AAS Education Task Force

Van Dixon, for the
AAS Committee for Sexual-Orientation and Gender Minorities in Astronomy (SGMA)
May 12, 2016

The AAS Education Task Force is charged with establishing the Society's priorities and plans for education, professional development, and public outreach. For several years, the Society has contributed to the professional development of its members by sponsoring workshops and special sessions on astronomy education. But a professor's responsibility to his or her students extends beyond the classroom. Professors serve as mentors, counselors, and advisors to undergraduate students, an age group that is often confronting questions of identity and sexuality. For students who identify as lesbian, gay, bisexual, transgender, intersex, questioning/ queer, or asexual (LGBTIQA), these questions can be particularly daunting. Their professors may be similarly overwhelmed. One of the most common questions addressed to members of SGMA is, "How can I be an effective mentor to my LGBT students? I want to be supportive, but I don't know what to say."

Many colleges and universities have instituted Safe Zone training programs to increase the awareness, knowledge, and skills of those who wish to advocate for their LGBTIQA colleagues and students. Unfortunately, Safe Zone training is not available at all institutions. At the Long Beach meeting in 2013, SGMA (then WGLE) sponsored a workshop entitled, "How to Be a Better Professor or Teaching Assistant for Your LGBT Students." The announcement read, in part:

> Do you feel sufficiently well informed about the issues facing your students who are lesbian, gay, bisexual, or transgender (LGBT)? If an LGBT student comes to your office hours asking for help, do you know how to respond? Do you know the warning signs of suicide or how to address bullying, issues that disproportionately affect LGBT students? Do you know how to discourage discrimination and cultivate an atmosphere of inclusion in your classes and in your department? This interactive workshop will help AAS members educate themselves about their LGBT students, learn what resources are available at their home institutions, and develop themselves as more effective mentors and allies to their LGBT students.

The Society can contribute to the professional development of its members by providing regular Safe Zone training at its meetings. Safe Zone trainers could be recruited from universities near meeting locations at minimal cost. With trans issues much in the news, this training would be both timely and potentially transformative.

The AAS and United States Planetariums: More Communication, More Cooperation, and Future Opportunities – A White Paper to the AAS Education Task Force
Dr. John Feldmeier, Associate Professor, Youngstown State University, jjfeldmeier@ysu.edu

One of the oldest forms of astronomy outreach in the United States (U.S.) is the planetarium – the first was created in 1913 (the Atwood Globe), just 14 years after the founding of the American Astronomical Society. Currently, there are over 600 and possibly as many as 1,500 planetariums in operation in the U.S.[1] They are a natural meeting place between astronomers and the general public, and are one of the places to inspire the next generation of astronomers. Given that many people in the U.S. live in urban environments, where light pollution is severe, planetariums may be one of the few ways the general public comes into contact with the constellations, and learn some astronomy. I have heard many astronomers mention a visit to a planetarium as young child being one of the events that sparked their interest in astronomy.

There are many locations where astronomers and planetarium professionals (known as planetarians) interact directly and closely collaborate. Some of these include major institutions such as the American Museum of Natural History[2] and the Adler Planetarium[3]. I'm also aware that NASA has made significant efforts to connect with the planetarium community[4]. There are also many university planetariums, where astronomy professors use the facilities for their classes and the planetarium gives shows to the general public[5]. In my own case, I have the good fortune of teaching my ASTRO 101 in class within the Ward Beecher Planetarium[6], which also doubles as a planetarium to K-12 students, and the general public. We have two full-time staff members in charge of producing and giving planetarium shows, and we see over 3,000 K-12 students and over 7,000 members of the general public annually.

However, these connections appear to be the exception, not the rule. Many planetarians are in isolated situations, with little support or funding. This makes it very difficult to stay current in the latest discoveries in astronomy. On the other hand, most astronomers are unaware of the planetarium system in the U.S. Although I have not done a formal survey, I am fairly confident that most astronomers do not know the following:

- That there is an International Planetarium Society[7], who publishes a monthly journal, *The Planetarian.*
- That there are several regional planetarium societies[8] located throughout the United States, with annual meetings. Some astronomers do attend these meetings, but not many.
- That planetariums in the U.S. are in a field-wide transition from optical-mechanical systems to digital full-dome systems, making planetariums a complex scientific visualization tool. Although this an exciting new capability, the shows used by these systems are expensive, and leads to many planetariums playing the same show over and over again. This is despite the enormous amount of free content created by astronomers for the purposes of outreach to the general public.
- That a significant number of AAS members have worked, or will work in a planetarium. As a recent example, we recently had a national job search at our own

planetarium, and received applications from people with Bachelors or Ph.D. degrees in astronomy.

This separation has led to both groups diverging, with little cross-pollination between the two groups. I think this may be an area where the AAS could both globally and locally make and strengthen the connections between the two groups for mutual benefit. At this time, I don't think we have enough information to make policy changes – I think the first step would be to learn how the two communities could benefit from closer cooperation. For example, astronomers could supply up-to-date information and professional advice to the planetarians, while the planetarians abundant experience with the public could better aid education and public outreach efforts that many astronomers do.

Some possible ways for the two groups to meet together and gain a better mutual understanding – ways that the AAS might be able to support with a modest effort would be:

1. Taking an inventory of already existing connections between AAS astronomers and planetariums. I am sure there are many other connections not mentioned in this document, and knowing the current landscape would be helpful.
2. Sending an appropriate AAS representative to the regional planetarium meetings, to both answer questions, and gather input from planetarians.
3. Having a special session at future AAS meetings, and invite planetarians from that geographic region to attend.
4. Providing discounted attendance to the annual meetings, and encourage planetarians to attend the press conference sessions announcing the latest discoveries. Perhaps, some sort of "ambassador" program might have a large impact.

I think it is highly likely that better communication could lead to better science education and public outreach, and ultimately get more people learning and get excited about astronomy.

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[1] See https://www.lochnessproductions.com/reference/attendance/attendance.html and https://www.lochnessproductions.com/lfco/lfco.html for some estimates.
[2] http://www.amnh.org/our-research/hayden-planetarium
[3] http://www.adlerplanetarium.org/
[4] https://informal.jpl.nasa.gov/museum/ - The NASA Museum Alliance is one important connection.
[5] See the Fiske Planetarium at the University of Colorado Boulder https://fiske.colorado.edu/ - as just one example.
[6] http://www.wbplanetarium.org/
[7] http://www.ips-planetarium.org/
[8] Some examples include GLPA (http://glpa.org/) and SEPA (http://www.sepadomes.org/).

WHITE PAPER

To: AAS Education Task Force **Date:** 12 May 2016

From: Rick Fienberg

Subject: "Those who cannot remember the past are condemned to repeat it."

As some of you may know, when I was hired by the AAS in 2009 my job was split 50:50 between Press Officer and Education & Outreach Coordinator. The latter half of the position was recommended in January 2009 by the Council Subcommittee on the AAS Education Program. That committee's report was informed in part by the Vision Statement and Strategic Plan for Education submitted by the Astronomy Education Board (AEB) a year earlier, in January 2008. I am providing copies of both documents on the pages following this memo.

No doubt these reports will give you lots of good background on AAS education efforts in the first decade of the 21st century, along with lots of good ideas from earlier incarnations of the Council and the AEB about what the AAS could be doing, should be doing, and/or shouldn't be doing in education.

The 2008 AEB report assumed the presence of a full-time AAS Education Director. When the Council recommended instead a half-time Education & Outreach Coordinator, they suggested that the program outlined in the AEB report should be reduced in scope accordingly. What actually happened is that the Education & Outreach Coordinator managed a potpourri of Executive Office programs that were related to education and outreach (in some cases just barely or perhaps not really at all) and/or that nobody else on the staff wanted to manage or was capable of managing. These included the Small Research Grants Program (now defunct), the Chambliss student poster competition at winter and summer meetings, the Doxsey travel prize competition, the Astronomy Ambassadors workshop program, and the Shapley Lectures.

Within a few years it became clear that the Press Officer job required my full-time attention, at which point Gina Brissenden was recruited to take over the role of Education & Outreach Coordinator on a half-time, contract basis. I suspect Gina would agree with me that she is not, in any real sense, running "the AAS education program." As I see it, and as I think she probably does too, the AAS doesn't really *have* an education program right now. Obviously that's where the Education Task Force comes in.

As I understand it, the previous Education Officer wanted the AAS to hire a new full-time Education Director so that the Society could have a robust education program. My feeling was that such a move would amount to putting the cart before the horse. I think we need to decide what the AAS education program should be, and only then hire someone (or multiple someones) to run it. The AAS had a succession of full-time Education Directors in the 1990s and 2000s. None lasted very long, and I think most left under less-than-happy circumstances.

What happened in each of these cases, I think, is that because the Council and AEB didn't have an agreed-upon idea of what the AAS education should be, the Education Director basically came up with his or her own program and ran it until the Council and/or AEB got upset because it wasn't the program they wanted (though they'd never been clear about what they wanted). That's what led to the 2008 AEB and 2009 Council subcommittee studies.

I encourage you to review those two reports, along with all the other input you receive, and come up with a recommendation for an AAS education program that the Council and AEB can endorse. Once that's done, and *only* once that's done, it'll be time to hire a person (or several people) to run the program.

Rick Fienberg

2000 Florida Ave., NW, Suite 300, Washington, DC 20009 rick.fienberg@aas.org | +1 202-328-2010 x116

(The below two documents are included within Fienberg's above white paper, not sent as separate documents; therefore, they remain here.)

VISION STATEMENT AND STRATEGIC PLAN FOR EDUCATION

American Astronomical Society
Astronomy Education Board

January 6, 2008

VISION STATEMENT AND STRATEGIC PLAN
American Astronomical Society - Astronomy Education Board

Preamble:

The Astronomy Education Board (AEB) of the American Astronomical Society is charged with leading the education mission of the society. Of the nearly countless aspects that could be done regarding the spectrum of education, and scientific communication in general, our society focuses on five key ideas that prepare students and support members in pursing a wide range of career paths. These are to promote and support: (1) training the next generation of astronomers to be successful scientific researchers; (2) training the next generation of astronomers to be successful educators; (3) research on the teaching and learning of astronomy; (4) increasing the scientific literacy of all and sharing the excitement of astronomy with the public; and (5) increasing the participation of underserved populations in astronomy. Without question, each of these goals is much easier said than done. However, the AEB members feel strongly that these goals are consistent with the overall mission of the AAS and that our AAS members in particular have knowledge, skills, resources, and inclination to work together to meet these important goals.

Priorities:

Of the many goals presented in this document, it is the consensus of the AEB that five are most urgent and should receive the highest priority. These are:

I: Nourish the AAS Community

1. Increase the pool of well-prepared, scientifically trained undergraduates by improving the attractiveness of astronomy, and science education in general, to meet the overall diverse needs of our society for technically trained individuals and to ensure the high quality of the next generation of astronomers
2. Increase access and pathways for underserved populations to participate in AAS activities
3. Expand training in teaching and outreach for graduate education and faculty professional development

II: Communicate Lessons Learned

4. Support Astronomy Education Review as the premier, scholarly vehicle documenting and disseminating research in astronomy education
5. Ensure availability of high quality, accurate, and effective astronomy information for public

Respectfully Submitted,

Timothy F. Slater, Ph.D., Education Officer, American Astronomical Society

Approved by AAS Council, January 6, 2008

GOAL ONE: THE AAS SUPPORTS AND PROMOTES TRAINING THE NEXT GENERATION OF ASTRONOMERS TO BE SUCCESSFUL SCIENTIFIC RESEARCHERS

Strategic Priority:
Undergraduate Support

1. Increase the pool of well-prepared, scientifically trained undergraduates by improving the attractiveness of astronomy, and science education in general, to meet the overall diverse needs of our society for technically trained individuals and to ensure the high quality of the next generation of astronomers
   - A. *Provide comprehensive, high-quality, and effective web-based information to students and mentors regarding:*
     - a. *career paths*
     - b. *graduate programs*
     - c. *summer research and other opportunities*
   - B. *Share best practices in mentoring and research among faculty and departments*
   - C. *Provide programs and opportunities for undergraduates at AAS and regional meetings including*
     - a. *highly publicized undergraduate reception at AAS meetings*
     - b. *awards program for undergraduate research*

2. Improve the training of astronomy graduate students for astronomical research as well as a wide variety of alternative research-related career paths, including research in astronomy education
   - A. *Provide comprehensive, high-quality, and effective web-based information to students and mentors regarding career paths*
   - B. *Share best practices in mentoring and research among faculty and departments*
   - C. *Provide specialized career workshops for graduate students at AAS and regional meetings*
   - D. *As appropriate, identify areas that need improvement nationwide and make recommendations to all relevant decision makers*

GOAL TWO: THE AAS SUPPORTS AND PROMOTES TRAINING THE NEXT GENERATION OF ASTRONOMERS TO BE SUCCESSFUL EDUCATORS

Strategic Priority:
Train Graduate Students and Faculty in Effective Education and Outreach

1. Increase the amount of training in pedagogy that is part of faculty enhancement and graduate education nationwide

   A. *On a regular basis, conduct dialogues and workshops at AAS meetings*
   B. *Collect and disseminate data on what graduate schools are doing in terms of preparing graduate students to teach and participate in outreach*

2. Increase the number of students who pursue science teaching as a career at all levels

   A. *On a regular basis, conduct dialogues and workshops at meetings*
   B. *Nurture strong partnerships with organizations like the ASP who support the teaching and learning of astronomy*

3. Develop the awareness and skills of college/university faculty and graduate students of their role and opportunities in preparing teachers and future teaching faculty

   A. *Provide resources and case studies highlighting best practices*

4. Enhance the awareness, skills and rewards of college/university faculty and graduate students of their significant role in education and outreach

   A. *Provide incentives and rewards that encourage participation of students and astronomers in educational activities*

5. Provide avenues to increase the quality of the education and outreach efforts of AAS members

   A. *Schedule and populate oral and poster sessions on astronomy education and outreach at every AAS meeting, as distinct from Astronomy Education Research*

GOAL THREE: THE AAS SUPPORTS AND PROMOTES RESEARCH ON THE TEACHING AND LEARNING OF ASTRONOMY

Strategic Priority: *Support Astronomy Education Review*

1. Increase the number of high-quality papers published by providing peer-reviewed forums for sharing methods and results of astronomy education research

    A. *Support Astronomy Education Review as the premier scholarly avenue for publishing results of astronomy education research*

2. Increase the number of oral and poster presentations reporting methods and results of astronomy education research at AAS meetings and maintain a distinction between research and educational activity reporting

    A. *Schedule and populate oral and poster sessions on astronomy education research at every AAS meeting*

3. Increase the number of individuals conducting and publishing high-quality astronomy education research

    A. *Include astronomy education research and researchers in SPARK, COMPADRE, the Shapley Lecture Series, recurrently as a plenary speaker at AAS meetings*

4. Increase awareness of AAS members about the value and nature of astronomy education research

    A. *Provide workshops, position statements, and awards for use by individuals interested in conducting astronomy education research*

NOTE: *In the domain of "Astronomy Education Research," we include research in all astronomy education venues including K-12, undergraduate, and graduate education well as informal education and outreach.*

GOAL FOUR: THE AAS SUPPORTS AND PROMOTES INCREASING THE SCIENTIFIC LITERACY OF ALL AND SHARING THE EXCITEMENT OF ASTRONOMY

Strategic Priority: *Public Information*

1. Ensure the availability of high quality, accurate, and effective astronomy content for the public

   A. *Provide information, tools and training for AAS members who conduct outreach, e.g., The Universe Booklet*
   B. *Support media outreach resources, e.g., Compadre's AstronomyCenter.org, that provide information to the public and educators*
   C. *Provide statements that communicate the AAS members' position on scientific issues*
   D. *Advocate for and promote funding of astronomy education and outreach*

2. Increase number of people that come into contact with astronomy

   A. *Provide current astronomy information for the media*
   B. *Engage members in astronomy public outreach programs, e.g., Shapley 2nd Century Lectures*
   C. *Build alliances with other organizations that offer venues for AAS members to conduct outreach, e.g., science center and museum organizations, science teacher organizations, etc.*

3. Increase the number of members who are actively engaged in outreach to the public

   A. *Provide information, tools, and training for AAS members*
   B. *Provide AAS recognition for members who engage in astronomy outreach*
   C. *Provide the AAS membership with avenues to conduct outreach via AAS programs and partnerships, e.g., collaborations with the ASP*

GOAL FIVE: THE AAS SUPPORTS AND PROMOTES INCREASING THE PARTICIPATION OF UNDERSERVED POPULATIONS IN ASTRONOMY

Strategic Priority:
Increase Access and Pathways

1. Increase access and pathways through education programs for underserved populations to participate in AAS activities and astronomy in general by (i) ensuring that the design of all AAS educational activities incorporate the best practices related to diverse populations and (ii) increasing the number of AAS members who incorporate this perspective in their scholarly endeavors.

   A. *Seek collaborations with AAS committees e.g. CSWA and CSMA, on cross-cutting activities such as increasing visibility at meetings such as SACNAS and AISES*
   B. *Develop and sustain meaningful partnerships in education with other societies*
   C. *Develop and sustain collaborative relationships with federal agencies' education offices.*
   D. *Annually review and assess AAS educational activities and materials*

ADDITIONAL PERSPECTIVES

THE AAS ADVOCATES

1. adequate and predictable financial support for education and outreach efforts of AAS members at all levels through efforts targeted at:

   A. *Continued awareness building among AAS members of current and future support levels*
   B. *Developing and communicating AAS recommendations to funding agencies regarding financial support*
   C. *Building awareness of and support for funding of astronomical research among the general public*

2. leveraging the innately intriguing topic of astronomy to improve
   A. *The public's interest in science and technology across all disciplines*
   B. *Students' interests and motivation toward pursuing science and technology based careers*

Report of the Council Subcommittee on the AAS Education Program

Executive Summary

We have reviewed the current educational portfolio of the AAS, the vision and goals articulated by the AEB and endorsed by Council, and consulted with the Executive Director regarding possible staffing opportunities and financial challenges. We recommend a restructuring of the educational staffing of the AAS from its previous arrangement to one which includes a) leadership/management of the AER; b) an additional 1/2 FTE at a leadership level to coordinate other educational activities; c) allocated staff support time for educational programs, and d) increased use of AEB and other members to support educational activities. The priorities of the education program should be those that increase communication among our members and/or promote their own engagement in education activities. Any new staffing arrangement should be reviewed for effectiveness in two years.

Background

The subcommittee's charge was to examine the AAS education program; to prioritize various activities; to determine "the level of resources appropriate for such activities"; and advise the Council on the allocation of resources, including possible replacement of the Education Director and developing and maintaining the AER. We interpreted the charge as a request for global, top-level recommendations while leaving detailed implementation of specific activities to the Executive Officer, the AEB, and the Council. As there may be a time-sensitive hiring opportunity, we have advanced our schedule to present our findings.

The committee conducted three telecons plus offline fact-finding about educational activities of other entities. Doris Daou contributed overviews of NASA and CASCA activities, and Sidney Wolff contributed overviews of educational efforts of AIP member societies; these are attached as brief appendices to our report, as they may be useful in future Council and/or AEB discussions. We did not review ASP activities, but this was not felt to be a problem, as several committee members are very familiar with ASP efforts, and that the relationship of and coordination between the ASP and AAS is long-standing. An electronic survey of attendees at the teaching workshops in Long Beach was conducted by Kevin Marvel. In addition, committee members conducted several one-on-one discussions with each other and with interested AAS members, and received several contributions from other interested, external parties with long experience of AAS educational activities, including Andy Fraknoi.

In setting priorities for the AAS educational activities, we concentrated on those characteristics that are unique to the functions of the Society. We feel that high priority programs should either:

Enhance the COMMUNICATION among Society members, in any appropriate form, such as meetings, workshops, journals and electronic media, in support of our professional activities. Communication allows both the sharing of information and development of effective professional communities within the Society working to common purpose;

and/or

Promote the ENGAGEMENT of Society members in pursuit of Society goals. Engagement facilitates the participation of more Society members and deepens their commitment to the goals, such as ensuring the health of the profession by encouraging students to pursue astronomy-related careers, improving the diversity of the profession, improving our own professional development in research, education and service, and educating the general public.

Recommendations

In light of the above, we considered the implementation of The Vision Statement and Strategic Plan of the AEB (hereafter AEB Statement), which has five goals: (1) training scientific researchers, (2) training astronomers to become better educators, (3) support research on learning of astronomy, (4) promote astronomy to the public, and (5) work toward increasing minority participation in astronomy. This leads to the following recommendations:

1) We recommend that first two goals of the AEB Statement, our highest priorities, using the specific means outlined in that statement, and considering the current financial situation of the Society, should be addressed in the near term without the addition of a full-time, top-level education director. There is a need for more staff support than currently available to coordinate information transfer, keep web-based material up to date, help organize meeting-related activities, and coordinate efforts with the AEB, other AAS committees, and outside organizations. We note that the survey of teaching workshop attendees at Long Beach indicated a high level of satisfaction with these workshops.

   The fourth goal of providing public information and outreach to increase scientific literacy is also a high priority of the AAS, and is the responsibility of the Press Officer as well as staff performing support for the educational activities. The AAS is in a position to make a unique contribution in this area, and the role of the Press Officer is important. Unlike the physics societies, which provide educational materials, astronomy has a funding agency (NASA) that appears likely to continue to provide substantial support for the development and dissemination of educational materials.

   The AAS should focus its efforts on increasing the engagement of Society members in public information and outreach as opposed to incremental additions to the large efforts by other organizations in direct production of materials.

   Concerning the fifth goal, expanding the access of diverse populations to astronomy, the prime responsibility for guiding activities rests with CSWA and CSMA. Education activities should be coordinated with those groups to the greatest extent possible.

   One-half FTE playing an education leadership and management role, with significant allocated time from support staff members and the active participation of AEB and other members, in addition to the management of the AER, are likely to provide a productive and appropriate level of education activities for the AAS. We note that the 2008 Vision Statement and Strategic Plan of the AEB was written with the assumption of a full-time education director and resources. Therefore, we recommend that the AAS Executive Officer establish goals commensurate with the reduction in time and resources available. We recommend that whatever staffing implementation is made by the Council and Executive Officer be reviewed again by a broad group after two years.

2) We recommend that the AAS actively monitor both the quality of the AER and the financial stake of the AAS in its publication. The AEB should be tasked to develop standards by which to measure the success of the AER. We support and encourage AAS efforts to make the AER successful in publishing and disseminating astronomy education research, which addresses the third goal of the AEB strategic statement. As a minor item, some consideration should be given to moving SPARK into the AER.

Committee members:

Doris Daou
Megan Donahue
Lee Hartmann, Chair
Larry Rudnick
Tim Slater
Meg Urry
Sidney Wolff

Margaret Hanson was unavailable for further consultation due to time constraints.

AMERICAN ASTRONOMICAL SOCIETY

Enhancing and sharing humanity's scientific understanding of the universe since 1899.

WHITE PAPER

To: AAS Education Task Force **Date:** 13 May 2016

From: Rick Fienberg

Subject: Professional-development workshops on teaching and learning

The weekend preceding most AAS meetings features workshops for "Astronomy 101" instructors. These tend to be offered by members/representatives of the Center for Astronomy Education (CAE) at the University of Arizona, the Center for Astronomy & Physics Education Research (CAPER) at the University of Wyoming, or alumni of past CAE or CAPER workshops.

The AAS also participates in the New Faculty Workshops held twice yearly by the American Association of Physics Teachers (AAPT) in College Park, Maryland. By "participates" I mean helps recruit and fund both presenters (usually drawn from CAE and/or CAPER, I think) and attendees from among our membership.

The goal of all such workshops is to turn attendees into better teachers with a better understanding of how their students learn. This seems, to me, like exactly the sort of thing the AAS should be doing, since a significant fraction of our membership teach intro astronomy at the college level.

I could be wrong about this, but I think the weekend education workshops at AAS meetings wouldn't happen if CAE and CAPER stopped proposing them for any reason. I think this would be a shame and that the AAS should try to find a way (i.e., a source of funds) to support these workshops at every AAS meeting.

Rick Fienberg

2000 Florida Ave., NW, Suite 300, Washington, DC 20009 rick.fienberg@aas.org | +1 202-328-2010 x116

White Paper (via email text)

Forman, Christine <cjones@cfa.harvard.edu>

Working to establish a resource archive for use in developing astronomy courses

While many colleges and universities offer astronomy courses, developing those courses is generally left to the individual astronomy faculty who will be teaching particular classes. These professors can often be the only expert in astronomy in a predominantly physics department. To help faculty develop new courses or revise existing ones, we propose to invite AAS member faculty to contribute their course material (lecture notes, keynote presentations, and possibly problems and exam questions) to a secure AAS website. This project would begin with a few courses similar to those that are widely taught in many departments (e.g. Planets in our Solar System and around other stars; The Life and Death of Stars (stellar evolution); Observational astronomy techniques across the magnetic spectrum; The Milky Way Galaxy and its place in the Universe (or Galaxies and Cosmology)

While each faculty would personalize the course material to suit their students and their teaching style, this resource archive would provide a foundation for designing new courses and improving existing ones.

“Science in Our Time”

--Peter Foukal

The importance of science in maintaining US economic competitiveness and security has traditionally justified its bipartisan support in Congress[1]. It is less well known that research now employs more Americans than does automobile manufacturing. So the interesting careers that science offers deserve to become a more prominent part of the argument for funding. Both of these justifications are worthwhile, but competitiveness requires a focus on excellence that may be less important in broadening inclusiveness. This distinction needs more attention if we are to make best use of resources.

We also need to better measure and understand trends in employment, talent and ethics that have occurred over the past generation. The review committees organized by the National Research Council have been successful at prioritizing expenditures, which is the principal mandate given to them by the funding agencies such as NASA, NIH or the NSF. But they rarely venture into broader topics. The need to achieve a panel consensus is one factor that limits progress on often more controversial issues[2].

Another is the understandable reluctance of many scientists supported on soft money to voice truths that the science community may consider inconvenient. This weakens the usefulness of many a painstakingly crafted consensus report. Retired scientists can feel more free to express views based on decades of research, teaching and community service. Many of us look back gratefully on satisfying careers in science; we owe it to future generations to pass on what we have developed and learnt.

Employment in Science

The instability of employment that has afflicted science since the 1970’s is the most important impediment to attracting talent. Past generations of scientists looked forward to life-long careers at universities or at national or major industrial laboratories. But in the post-Sputnik era the supply of Ph.D.’s soared four-fold relative to population. When Federal funding collapsed after the Cold War ended, scientists had to accommodate to a new landscape. For decades, an increasing fraction have been supported on relatively short- term “soft money” grants from Federal agencies. Many have had difficulty reconciling themselves to this gap between career expectations and realities [3-6].

It is surprising that the scientific associations do not keep statistics on this key trend toward soft money support. In fact, contradictory information on the need for more scientists has been part of the problem that created the gap, and may also have contributed to decreasing the caliber of scientists [5]. It has even been suggested [6] that well- intentioned STEM activities at schools *exacerbate* the gap by drawing more students into science than are needed by employers, thus weakening the market and making the careers less, rather than more attractive. Such an effect needs to be balanced against our aims to improve science literacy in the wider public.

Scientists are not alone in experiencing this gap between expectations and reality. The career plans of young doctors and lawyers have also required adjustment; in the business community not even Toyota promises life long careers anymore. But these fields seem to have heard the message and moved on, especially into entrepreneurship. Many doctors, for example, own or consult for, medical testing or biotech firms. The science community, on the other hand, still places its faith on requests for increased Federal funding [7].

The Scientist as Entrepreneur

Governments worldwide are encouraging scientific entrepreneurship [8]. The Small Business Innovation Research (SBIR) program has provided well over $40 *billion* in research support to small profit-making businesses that is not available to universities [9]. Moreover, young US scientists benefit from essentially free graduate education, unlike lawyers, doctors, and MBA's who often incur considerable debt.

Despite these perks, few Ph.D. scientists, even in the life sciences, have the appetite to pursue their research as entrepreneurs. Nevertheless, their number may be comparable to the (also) few who will achieve academic tenure. Success stories such as American Science and Engineering, Inc., where Nobel-prize winning astrophysics led to the invention of x- ray scanning equipment, and Cambridge Research and Instrumentation, Inc., where solar astrophysics led to wavelength – agile imagers for biomedical applications, might help convince more Ph.D.'s that entrepreneurship can narrow the gap between expectation and reality [10].

Efforts to promote entrepreneurship presently focus on getting research results to market through spin-offs from universities and Federal labs. But for young scientists this still looks like leaving their research career and learning about marketing, manufacturing and finance. Few scientists realize that blue - sky research and commercialization can co-exist perfectly well under the same roof; entrepreneurship does not require leaving a research career.

Can Too Much Funding Damage Science?

A connection between the number and importance of scientific advances, and the size of the national science budget is difficult to demonstrate, although efforts to develop appropriate metrics are underway in Washington [12]. So it is not surprising that the US science community has avoided this tricky issue [13,14]. Recently the Chinese, it appears, have helped to provide an answer. They tried tripling science funding over a decade but found little improvement in the quality of research and of its international impact [15]. Better results seem to have been obtained since 2006, by focusing more on how resources are spent.

More money certainly employs more scientists and funds more facilities and instruments [13-15] but as the Chinese found, this doesn't necessarily translate into quality research. The $19 trillion US Federal debt makes efficiency a consideration [14], yet the concept of *optimal* funding is seldom discussed in science planning circles. Every enterprise encounters diminishing returns at some point: At what funding level does the dependence of US science quality upon funding flatten out and perhaps even start to decrease?

If excellence rather than just numbers employed is to drive science funding, then we need to get serious about the factors that inevitably reduce returns. For instance, the supply of clever people *interested in science* is finite [5]. Too much funding tends to push the best out of research and into management of the less able; the appetite for more administrators in academia appears to be boundless. Great care is required to avoid duplication of effort and resources. Otherwise, not only productivity but even aggregate output may actually drop.

The merit of such ideas needs investigation. But it does not reflect well on the science community that the connection between funding and quality of US research is presently left pretty much to the imagination.

Bigger Isn't Necessarily Better

Large increases in funding are usually associated with major new projects because the agencies favor novelty and initiatives that secure wide community involvement. Big projects are also easier to manage than many small grants. In addition, the private foundations which now underwrite many of the largest initiatives in biomedical research or astronomy prefer them because they generate more visibility. Consequently, Big Science has grown disproportionately at the expense of smaller- scale research [16].

Putting too many eggs in one basket can, however, be dangerous. Particle physics, for example, was the flagship of the scientific enterprise in the 1950's and 1960's. But when over-runs doomed the multi-billion dollar Superconducting Supercollider, the field imploded and hundreds of particle physicists switched to astrophysics or to working for Wall Street [17]. A similar flame - out could befall US astronomy, where the largest facilities of 10 years ago may now be mothballed to build two colossal ground based instruments [18,19] and a giant solar telescope [20]. One of these projects is now held up indefinitely by Native Hawaiian concerns. Small and moderate- sized space missions are being edged out at NASA by big over- runs on the flagship James Webb telescope [21].

Big Science has its place, as in the study of gravitational waves. But General Relativity can also be tested on a table top [22]. In the rush to embrace Big Science, even elementary school children are being taught that good science requires collaboration in large groups [23] This shaky assertion overlooks that the 2010 Nobel prize in physics was awarded for discovery of graphene, using a roll of Scotch tape. Also, quantum entanglement and its relation to string theory, probed by a handful of theorists [24], looks as exciting as the discovery of the Higgs boson by a cast of ten thousand [25].

In the business management world, where the emphasis on collaboration originated, the enthusiasm for "open" offices and "visioning" meetings is waning [26]. Many scientists would gladly trade the next collaborative mega - project for another solitary Einstein or Darwin, or even just some time to think… alone. [27].

Studies have shown a link between skill in science and autism [28]. More generally, telling the young that science is a group activity is not helpful because many of the most talented look to mathematics and science to express their individuality. Science cannot match the financial rewards of hedge funds. If we remove the promise of individual recognition, even fewer of the most talented will have little reason to choose science over the financial sector. It makes more sense to tell the truth: The best science comes in all shapes and sizes; it always has and always will.

Deduction and Induction

If we are to broaden participation in science, we need to clarify the reasons for lower female representation on faculty in the mathematical and physical sciences. It is encouraging that some of the past explanations such as child care burdens are being set aside as new evidence emerges [29,30]. While the possible role of prejudice should not be neglected [29], even a century ago it did not prevent Marie Curie from being one of only three people to ever be awarded *two* Nobel prizes - for physics in 1903, and again for chemistry in 1911. So more creative thinking may be required to find the real answer.

In this connection it may be useful to recall that a distinction was made, already by the Greeks, between deductive and inductive reasoning. In our education we focus on the former; those most skilled in *deducing* the correct solution from a limited set of axioms are considered most clever [31]. But except in mathematics and some of its applications to theoretical physics, progress more often requires the ability to assimilate many competing facts. This ability to proceed by *induction* from the general to the particular requires a different kind of cleverness that is harder to test amongst undergraduates, but becomes more evident in graduate research.

It is interesting that women are best represented in fields rich in phenomenology like astronomy and biology, where inductive reasoning is most important. For instance, Cecilia Payne - Gaposchkin, the first female professor of astronomy at Harvard (who discovered that the sun was made mainly of hydrogen), reputedly had an amazing ability to carry around in her head the wavelength spectrum of every star she had ever studied. Unfortunately for female tenure candidates, inductive skill is often less valued in academia than deductive wizardry. The physicist Richard Feynman, for instance, could solve difficult puzzles faster than smart colleagues could describe them. For better or worse, such virtuosity is what tenure committees find most impressive.

Women have, over the past two decades, directed most of our prestigious scientific institutions such as the National Science Foundation, the National Oceanic and Atmospheric Association, the National Optical Astronomy Observatories, the European Southern Observatories, and the Woods Hole Oceanographic Institute. The National Academy of Sciences has recently joined this list. So the appearance of prejudice in university faculty positions seems more likely to reflect a lesser value placed in academia on inductive reasoning, than any general bias against women.

If we recognized the importance of inductive reasoning more openly we might move toward spotting and training of inductive cleverness in both women and men [32]. This is a tide that would lift all boats [33]. Whether such new ideas have merit can only be determined by open discussion and research.

Ethics: Walking the Walk…

Concerns about a decline in research ethics are of particular importance in preserving the attraction of science careers, especially to the young. The focus has been on high- profile cases of data manipulation. These are reprehensible and deserve the prosecution that they receive, but they are too rare to have much effect on the march of science.

We should pay more attention to the ways in which we encourage lower- level fraud. The practice of asking young researchers to write their own letters of recommendation to save their advisors' time, is one example. Such encouragement on the grounds that "everyone does it" is the thin edge of the wedge that leads to more serious fraud later [34]. Another is the publication in *Science* and *Nature* of often trivial findings obtained by expensive projects, to give a false impression of important break-throughs.

Scientific integrity rests on willingness to consider all evidence, even when it may be politically inconvenient. The case against pseudo-science rests largely on allegations that deniers of climate change or of Darwinian evolution suppress inconvenient evidence. So it is damaging to the integrity of science to suppress mention of research on gender differences in ability in mathematics and science. Such research is actively pursued by well- regarded psychologists at prestigious universities with support by Federal agencies [35]. It deserves to be aired as openly as any other scientific results. Yet its very mention is sufficient, as Larry Summers found, to bring down the President of Harvard University.

Deniers watching this spectacle observed that scientists happily tolerate the suppression of evidence that they find inconvenient, so they wonder why their own sins are singled out. The science community needs to take a more consistent stand on this topic; the traditional integrity of science is one of its attractions to the young.

Communication with the Public

Scientists are finding widespread resistance from the US public, to their findings on evolution, climate change and health issues [36]. It would help to recognize that both the public and also scientists themselves, generally rely more on their trust in the spokesperson, than on the details of the argument. Few of us, even in science, have the expertise or time to follow the often complex evidence behind many of the findings we hold dear.

The public is actually very open to new ideas presented by someone whom they trust. Trust is most often earned through shared values and prosaically enough, through joint participation in community, sports, and religion. The recent initiative by US churches to involve Baptist ministers in explaining evolution is a step in this direction. More broadly, people are more impressed by what others do, than what they say. Scientists whose conduct of their personal affairs gains the confidence of their neighbors stand a better chance, over time, of influencing their community's views on science than the most passionate activist.

Education

The science community supports research on educational methods. Real improvements in teaching STEM subjects in particular, would certainly be welcome. But we need to become more aware of the disruptive effect of constantly overhauling curricula and pedagogy.

The stress that teachers face in keeping a class of 25 or more youngsters engaged for 6-7 hours a day is already considerable. The additional pressure of dealing with their often obsessive parents further limits a teacher's enthusiasm for learning yet another newest way of teaching math.

Research in science education can, when applied reasonably, be useful. But it has become an industry with its own agenda that is not always attuned to the needs of experienced teachers. It is doubtful whether children of differing ability levels are acquiring STEM skills any better now than in the 1950's, before the post – Sputnik race for STEM improvement. Scientists need to be more aware of the real needs of the many devoted teachers who cope with the nation's often demanding progeny, day in and day out.

Trends in Scientific Method

We are taught that a hypothesis must be tested experimentally to become a theory. This tenet is now being questioned by string theorists whose work may not be observationally falsifiable. This development in cosmology and particle physics has attracted attention [37] but its overall impact is probably less than the effects of lower- profile developments in Scientific Method.

The increased tendency to report results that are "consistent with previous findings" is one such trend. The tenet that a theory cannot be proven correct, only falsified, has been influential since it was first enunciated by Karl Popper in the 1930's. Nevertheless, research results seem to now increasingly focus on how findings *agree* with previous findings, rather than more usefully testing whether they *disagree*.

This trend may be caused by the number of scientists rising faster than the supply of well-posed problems. Such a mismatch encourages the preservation of a limited supply of unanswered questions. This is a trend worth investigating; we should not be surprised at this development if stable employment has become, in our time, as much an aim of science as advances in understanding.

Summary

It is sometimes claimed that "science has changed". It is unlikely that the Universe has suddenly decided to play by different rules. But as world population grows the pressures increase on science to evolve from the magical, individual contemplation of nature that has been its heritage since time immemorial, to become yet another Big Business. The talented young who consider science as a career should be re-assured that this trend is not inescapable. It just takes a little more vision and perseverance to find the old magic.

Peter Foukal (pvfoukal@comcast.net)

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White Paper for the AAS Education Task Force

A Free High-Quality Open-Source Textbook in Astronomy

Andrew Fraknoi *(Foothill College)*,
David Morrison *(NASA Ames Research Ctr.)*, and
Sidney Wolff *(NOAO)*

During a four year period, roughly a million students take Astronomy 101 classes in the U.S., making the Astro 101 classroom one of the largest intersections between astronomers and the voting public.

For many years now, the AAS (as well as the Astronomical Society of the Pacific) has concerned itself with Astro 101 teaching, encouraging discussions about it at its meetings (including a widely-praised series of hands-on workshops) and publishing papers and abstracts about research and practice related to the course. We think there is wide agreement within the AAS membership that considerations of teaching astronomy have an important role in the mission of the Society.

One problem frequently discussed at AAS meetings and workshops has been the high price of astronomy textbooks -- coupled with the complexity of the national used-textbook market and its relationship to those high prices, and the constantly revised editions of existing textbooks that publishers produce.

For the last year, the three of us have been engaged with a promising new project that may change the landscape of astronomy textbook publishing. We thought the Task Force may want to know about it.

Nonprofit publisher OpenStax (https://www.openstax.org/higher-ed) publishes free, high-quality, fully-developed college textbooks in fields that many undergraduates take (physics, math, economics, etc.) It is able to do this because of significant funding from a variety of foundations around the country (see list below.)

We are doing an Astro 101 text through them, with the help of about 75 astronomers and educators from around the country. Based on our earlier text, *Voyages through the Universe,* it has been thoroughly revised, updated, reviewed, embellished with weblinks, and put on a standardized electronic platform.

The first electronic edition (free to students) should be available by late summer 2016. Paper copies will be sold at cost. Since it is open source (including the images,) each instructor will be able to make his or her own electronic version of the book, leaving out chapters or sections, adding their own material or syllabus. Local distribution can also be done electronically and the book will be available on a variety of platforms. A range of ancillary materials is also being prepared, but may take a bit longer to be available.

(OpenStax is supported by Rice University, the Laura and John Arnold Foundation, Bill & Melinda Gates Foundation, the William and Flora Hewlett Foundation, the Calvin K. Kazanjian Economics Foundation, the Maxfield Foundation, the Bill and Stephanie Sick Fund, and the Michelson 20 MM Foundation.)

Astronomy Education and the American Astronomical Society

Andrew Fraknoi
(Foothill College & the Astronomical Society of the Pacific)
and
Donat Wentzel
(University of Maryland)

Final version: 7-14-1997

It seems fair to say that the American Astronomical Society -- considering itself primarily as an organization of *research* astronomers -- has had an ambivalent relationship with the world of astronomy education. While some members have felt that it was important for the Society to play an active role in this arena, many others looked upon educational work with disinterest and even disdain. Some officers of the Society occasionally advocated significantly greater AAS involvement in education, but the Council rarely followed up with the sustained political will or the resources needed to bring about effective change.

Our examination of Society records and publications shows that enthusiasm for astronomy education seems to have come in cycles -- with periods of more concentrated activity alternating with stretches of unmourned inactivity. As summarized in Table 1, some education committee or task force would generally begin with great enthusiasm to reform or revive some aspects of education, only to fade away after a few years as its leaders became tired or felt that they did not have the support of the community. Then, often after a dormant period, a new generation of "reformers" would tackle the same issues (occasionally even using the same language and the same suggested solutions as their rallying cry), only to fall prey to the same problems or lack of support. And when the Society' leaders did take a more active interest in educational matters, it was often motivated (as it appears to be at the time we are writing this history) by concerns over jobs for astronomy graduates, and whether there were too few or too many astronomers to fill the positions then available to them.

Such ambivalence may be natural for a Society whose primary aim is encouraging research, but it also means that the kind of national coordination that has helped many of the research branches of astronomy become more effective has frequently been absent in the field of astronomy education. Despite many good educational initiatives from the AAS over the years, such lack of coordination continues to hamper efforts to improve astronomy education even today. We note that there has never been a journal or magazine devoted to astronomy education, and that some of the most important symposia in the field have been organized outside the aegis of the AAS (although they then frequently obtained AAS co-sponsorship for the prestige it afforded.)

Table 1: AAS Educational Committees and Groups

Name	Dates of Existence	What Happened To It?
Committee on Cooperation in the Teaching of Astronomy [changed to the Committee on the Teaching of Astronomy]	1911-1921	Abolished by Council [was inactive at end]
Teachers' Committee	1941-1956	Dissolved; Chair had resigned saying there was a stigma attached to helping the committee
Committee on Education in Astronomy	1957-1972	Dissolved after the TGEA was appointed
Task Group on Education in Astronomy (TGEA)	1972-1985	Education Officer took over many of its tasks
TGEA Advisory Board [soon becomes Education Advisory Board]	1975-1997	Replaced by Education Board
Working Group on Astronomy Education	1991-	
Ad Hoc Committee on Education [chaired by S. Edwards]	1993-1994	Evolved into the Education Policy Board
Education Policy Board	1994-1997	Replaced by Education Board
Education Board [combines the Education Policy Bd. & the Education Advisory Bd]	1997-	

Defining Astronomy Education

One crucial question, which was to emerge again and again in the relationship of the AAS and astronomy education, was what the term was to mean. To many astronomers, especially in the early years, astronomy education meant the training of new astronomers. If any aspect of education was to place a consistent hold on their attention, it was this issue of how to produce world-class scientists at a time when sources of support for the training of scientists were still meager and intermittent.

Yet from time to time, the question would come up whether a broader scope for the Society's educational purview was not necessary. Should not the AAS also concern itself with what we today call "general education courses" in college, with K-12 education, and with public education (through the media, through planetaria and museums, and other ways of reaching a much broader segment of the American public)? We shall see that there has been a gradual expansion of the scope of the Society's educational efforts with time. There were several periods, especially in the 1950's and 1970's, where groups within the Society clearly advocated taking a broader view of the appropriate purview for the AAS and undertook projects to help those working in these larger domains. Nevertheless, this question still remains a vexing one for a Society with limited resources, and recent AAS committees and Councils continue to grapple with it.

Still, our history will end on a hopeful note, since as the AAS Centennial draws near, the Council has voted a specific dues increase dedicated to expanding the Society's programs in education and has hired (for the first time) a paid education coordinator to spearhead these efforts.

The Early Days

The birth of the AAS corresponded to a generally discouraging time in astronomy education in the U.S. A series of academic conferences arranged by a group of ten college presidents and high school principals, known as "the Committee of Ten," in the last decade of the 19th century -- reflecting broad trends in educational reform -- had recommended (among other things) that astronomy be eliminated as a required course for college admission, and that physics, chemistry, and biology be emphasized. As an elective course not required for college, what little astronomy was still offered soon suffered from lack of enrollments, and the subject eventually disappeared from the curriculum of most high schools and thus from the preparation of most elementary school teachers as well.

As a result, between the years 1900 and 1915 astronomy suffered a "precipitous decline in high school and college." <<Bishop, J., *Griffith Observer,* March 1980, p. 2.>> The inertia from these early school reform efforts left both pre-college and college astronomy education for non-scientists in a state of disarray and impoverishment from which it did not really recover until the Sputnik era ushered in its wave of funding for expanded science training.

The first record we have of an education paper at an AAS meeting was given by Sarah F. Whiting of Wellesley College at the Society's fourth meeting, in December 1902. The paper is listed by title only: "Astronomical Laboratory Work for Large Classes." <<PAAS, 1, 210, 1910 >> She gave another education-related paper at the seventh meeting, but there is little record of other members following suit.

During the course of the twelfth meeting in August 1911, the Council appointed a Committee on Cooperation in the Teaching of Astronomy, chaired by C. L. Doolittle of the University of Pennsylvania. One of the committee's first tasks, in 1912, was to undertake a survey of the availability of astronomy courses at a range of colleges and universities.

The circular for the survey began with an eloquent statement that seems as appropriate today as it was almost a century ago: "At its late meeting in Ottawa, [the Society] was mindful of the fact that the advancement of science depends not only on the discovery of new truth, but on the diffusion of knowledge, and the scientific spirit which creates a friendly atmosphere for its reception. The Society considered the deplorable ignorance of persons, otherwise intelligent, in regard to the everyday phenomena of the sky, and the fact that astronomy lags behind the other sciences in adopting the modern method of laboratory work by the student." The 80 replies received, the committee reported, were disheartening. "Only a very small proportion of college men and women know much about anything off this little planet." <<Whiting, S. F., PAAS, 2, 145, 1915.>>

The committee asked for the assistance of the Society in devising constructive plans for improving the situation, but no further reports on this subject appear in the Society's publications and the committee was abolished (with a list of other inactive groups) at the 26th meeting in 1921.

In 1915, the AAS held its 18th meeting in San Francisco and Berkeley, in what was to be the first of several joint meetings with the Astronomical Society of the Pacific (ASP). The ASP had been founded ten years before the AAS as an outgrowth of the cooperation between professional and amateur astronomers during the eclipse of Jan. 1, 1889. Despite its regional name and origins, it would grow to be a national and international group, but it differed from the AAS in that it invited and accepted membership from everyone interested in astronomy and made public outreach a main concern from the outset. <<Bracher, K., Mercury, 14, no. 5, 1, 1989>> In later years, a number of the AAS education projects would be undertaken in cooperation with the ASP.

A Wartime Revival

After the demise of the Committee on the Teaching of Astronomy (as it was known by 1921), astronomy education was absent from the published records of the AAS for almost two decades. However, this changed during the years of World War II, when the need for trained "aerial navigators" made astronomy education a defense-related issue.

During the 66th AAS meeting in September 1941 at Yerkes, more than 70 teachers of college-level astronomy attended a Sunday afternoon conference and discussed a wide range of problems and techniques. On the agenda were the spelling and pronunciation of star and constellation names, finding appropriate laboratory materials and textbooks, the problems of switching from the old lantern slides to Kodak's new compact 2x2 design, and combating astrology (with a skeptical talk by Allen Hynek.) Both the well-established *Popular Astronomy* and the new *The Sky* (which would later merge with *The Telescope)* expressed interest in publishing articles on the teaching of astronomy. An unofficial committee, chaired by J. H. Pitman of the Sproul Observatory, was appointed to continue the work of the group and plan future meetings. <<Pitman, J., Popular Astronomy, 49, 531, 1941>>

At the 67th meeting in December 1941, this Committee held three meetings and agreed that its "ultimate aim is to devise means for the encouragement of the teaching of astronomy in American Colleges and Universities, having in mind that its value lies, not only in its broad aspects of understanding the workings of the universe, but also in its cultural aspects". <<Williams, M., Popular Astronomy, 50, 65, 1942>>. This AAS meeting, by the way, was -- it appears -- the first to feature a public lecture. Harlow Shapley gave a talk at Cleveland's Severance Hall on "Galactic Explorations with Newer Telescopes".

At the 68th meeting, the Council formally accepted the group that had been operating for about a year and designated it as the AAS Teachers' Committee. For several meetings, the group would organize sessions on astronomy education and the war effort and sponsor talks and discussions on teaching navigation effectively. At the 69th meeting in December 1942, for example, they offered a symposium on "Science Courses in the War Effort" with several military instructors in attendance. Even after the war ended, "Teachers Conferences" (where teacher meant college or university professors) were regular parts of AAS meetings. (And in the era before simultaneous sessions, this meant that the full meeting was "turned over" to the Teachers' Committee.)

The 72nd meeting in June 1944 featured a discussion on what sort of astronomy should be taught in the post-war liberal arts colleges. "Those actively engaged in teaching are evidently far from being perfectly agreed on just what should be emphasized and how it should be taught, but this is a healthy sign..." <<McLaughlin, D. B. *Popular Astronomy,* 52, 313, 1944.>> Not much has changed in this respect in the intervening half century, we note! At the 80th meeting in 1948 there was again a broad discussion on the astronomy curriculum in American colleges and universities.

The 1950's: The Era of the CEA

By the mid-1950's, however, much of the intensity of the war years was forgotten and the country settled into a more routine existence. The AAS resumed its strong focus on astronomical research and instrumentation. Freeman Miller, an active member of the Teachers' Committee between 1948 and 1954, recalls that he and Allan Hynek were often "fed up with lack of support by the Council [for the Teachers' Committee]." He remembers that they did "pry enough money from the Council to circulate a questionnaire to all astronomy departments, asking about their interests in education; possibly the response contributed to our feeling of lack of interest." <<Miller, F., private communication>> Between 1953 and 1956, committee members did write an occasional column called "Sky & Teacher" in *Sky & Telescope* magazine, however, to keep the astronomical community aware of educational projects and issues.

At the 92nd meeting, in April 1955, the Council was asked to pass a resolution in response to a National Science Foundation panel considering "the relation of astronomy to the general public". The resolution read in part, "It is the opinion of the panel that astronomy does not fare as well in [this area] as many of its sister sciences, and that more attention should be given by professional astronomers to matters of inspiring future public and government understanding, interest in, and support of astronomy....The Council of the Society, therefore, recognizes that a definite need exists for the dissemination to the public at large of accurate astronomical information, consistent with the dignity of the science; deplores that, in the past, some stigma appeared to be attached to such activities; and recommends that astronomers devote reasonable time and effort to the preparation of popular, non-technical articles and lectures on astronomy and closely allied topics." <<AAS Council minutes, p. 629ff >>

The problem the resolution referred to was dramatically illustrated just two meetings later, when the Chair of the Teachers' Committee, Carl Bauer of Penn State, resigned, saying that he had had trouble getting cooperation from members in setting up an educational session for the meeting. Bauer's words, as reported in the Council minutes, were that "it appeared as though these members felt that a certain stigma attaches to being asked to do something for the Teachers' Committee." <<AAS Council minutes, p. 657>> The Council expressed surprise and appointed a panel of former Teachers' Committee Chairs, headed by Helen Dodson of the University of Michigan, as an advisory committee on educational policy.

After hearing the report of the Dodson committee at their next session (the 95th meeting of the AAS in late 1956), the Council dissolved the Teachers' Committee and established a new Committee on Education in Astronomy (CEA), whose members would be appointed at the following meeting. It was during the same Council discussion, by the way, that the first suggestion of what would eventually become the Shapley lectures was first raised. (The concept was borrowed from an NSF-sponsored program at the American Mathematical Society, and would involve visits from astronomers to smaller or less research-oriented colleges, often ones without active astronomy programs, to encourage the appreciation of astronomy by faculty, students, and the public.) The AAS' project began in 1957 with the help of the NSF, and was first called the "Visiting Professors Program". Renamed in honor of Harlow Shapley after his death, it continues today as one of the Society's most visible contributions to the public understanding of science.

The new CEA was appointed at the 97th AAS meeting in 1957, with Joseph M. Chamberlain (then of the Hayden Planetarium in New York City) as its chair. The original members included such well-known names as Otto Struve, Carl Seyfert, Stanley Wyatt, and William Liller. The first years of the CEA coincided with the time of Sputnik, the concern in the U.S. that the country was falling behind in science and technology, and the infusion of significant federal funds into both science and education. It was not surprising, therefore, that many of the Committee's first activities dealt with what by 1960 was being called "the national shortage of astronomers" and with projects most likely to encourage more young people to enter the field. As the times changed in the 1960's, the CEA would broaden its mission to focus more on astronomy teaching and outreach for non-scientists.

It was the CEA that began a number of the education and outreach programs that AAS members today associate with the Society. Among these were the "Careers in Astronomy" Brochure, first written by Struve and Gibson Reaves, which remains to this day the Society's most widely circulated publication. (In the first year and a half after publication, some 12,000 copies were distributed.) Two college level films on astronomy were produced with NSF support. A Foreign Visiting Professor Program broadened the outlook of many American graduate students by bringing astronomers from other countries to work at universities in the U.S.

The CEA debated the need for a newsletter on astronomy education, but decided that it was not worth the time and expense that would be involved <<AAS Council minutes, pp. 779 & 829.>> Instead, members from larger institutions were encouraged to invite members in smaller schools to colloquia and other activities and to foster better communications among Society members engaged in educational work in whatever way they could. The lack of effective communication among astronomy educators at all levels remains a problem to this day.

Thornton Page represented the AAS and the CEA on a Cooperative Committee at the American Association for the Advancement of Science (AAAS), the umbrella group of U.S. scientific societies, which was then making recommendations for the reform of high school science education. The Council minutes report that ..."through Dr. Page's efforts, astronomy is now listed separately in AAAS curriculum guides, rather than as a happenstance item under general science." <<AAS Council minutes, p. 877>> (Where to fit in seems to be a perennial problem for astronomy; in the new National Science Standards promulgated in the 1990's, astronomy wound up mostly under the Earth Sciences instead of the Physical Science headings.)

In 1960, the Council discussed at length a report by Captain Carl Christie of the U.S. Navy on the need for more people with astronomical training (not necessarily only PhD's) and referred its recommendations to the CEA. Chamberlain dutifully gave a report at the December 1960 Council meeting on what could be done to implement the Christie report, but many of the suggestions proved to be controversial and expensive. For example, the Council declined the proposals to keep track of statistics on graduate and undergraduate enrollments in astronomy programs, to appoint education representatives in each department or observatory, and to set up national programs of scholarships and fellowships through the AAS. <<AAS Council minutes, p. 893ff>> One has to see the reluctance of the Council in the right context however; this was a time when the work of the Society was done entirely by volunteers and any new tasks would fall on the shoulders of such volunteers or would require grants to be written by volunteers to NSF. Indeed, it was discussions like the one generated by the Christie report that led the Council around this time to explore the idea of a paid executive officer for the first time.

Conferences and Workshops

As part of the implementation of the Christie report, the CEA sought NSF funding for a conference on graduate education in astronomy, which was held in October 1962 at Indiana University. Organized by Chamberlain and a committee that included Donald Osterbrock, Lyman Spitzer, Jesse Greenstein, and Harold Weaver (all of them future officers of the Society), the conference brought together representative faculty and administrators from many institutions. <<Chamberlain, J.M., Astronomical Journal, 68, 215, 1963>> Participants discussed the goals of graduate education, the curricula needed to achieve these goals, and the problems of recruiting outstanding students for the field. As George Abell summarized the conference a few years later <<Abell, G., BAAS, 2, 254, 1970>>, "there was considerable disagreement about what the curriculum should be, and there wasn't even great agreement on what the goals should be." However, departments learned a great deal about how other institutions operated, and some curricular changes were made at both the graduate and undergraduate level, especially as they related to the importance of a good background in physics to modern astronomical research. (Interestingly, a similar set of conferences would be held by the AAS in 1996, but responding to an employment crisis of opposite direction -- not too few astronomers but too few jobs.)

In August 1969, at the 130th meeting, the CEA sponsored a conference on educational issues, the first such conference held as a regular part of an AAS meeting for well over a decade. After a keynote address by then CEA Chair Abell, six other speakers considered various aspects of astronomy education from the graduate to the K-12 level. <<BAAS, 2, 254ff, 1970>>

In his eloquent review, Abell brought out a number of the issues facing those concerned about astronomy education in the late 1960's, including lack of training in modern astronomy among many community college, high school, and elementary school teachers, planetarium staff, reporters, and college graduates in general. He discussed the increasing growth of unskeptical belief in such pseudo-sciences as astrology, problems with the difficulty of some of the science reform curricula which had been devised in the 1960's, and the issues of student dissatisfaction with some of the features of the college education system (large lecture classes, memorization of facts as a prime standard for good grades, and the lack of relevance in the curriculum). He admonished his colleagues that "if we do not turn our attention somehow to finding solutions [to these problems], we may find that science in general, and astronomy in particular, will suffer from a grave lack of support." These were prescient words, perhaps even more relevant in our own era of shrinking budgets and growing public expectations than they were in the turbulent

1960's.

Independently, Elske v. P. Smith and Don Wentzel (both of the University of Maryland) organized a workshop, one day after the same AAS meting, on laboratory exercises in astronomy aimed at college non-science students <<Ross, S. Sky & Telescope, Nov 1969, p. 304.>> To everyone’s surprise, the 90 attendees included not only the astronomers who had been teaching non-science students but also much of the leadership of the AAS.

In 1971, with the sponsorship of the AAS and the N.Y. Academy of Sciences, Richard Berendzen, then of Boston University, organized a major conference on Education in and History of Modern Astronomy at the American Museum of Natural History. There were sessions on many aspects of education, from graduate training to planetarium shows, in the U.S. and abroad. The published proceedings of this conference stand as perhaps the best summary we have of the state of astronomy education in the 1960's. <<Berendzen, R., Annals of the N.Y. Academy of Science 198, 5ff, 1972>>

Abell was again the lead speaker, and expressed his vision of the most urgent need in astronomy education: "Far more serious today is the problem of selling astronomy to the public at large. Ultimately, the support of our science rests on the public's willingness to pay our salaries....In the past, we have tended to leave it to others to carry the message of astronomy to the outside world, but now, as the public becomes increasingly disillusioned with science and concerned over increasing taxes...astronomy in the U.S. is losing support. Consequently, we have a responsibility to concern ourselves deeply with the problem of representing astronomy honestly and accurately to the public, and, hopefully, to gain appreciation and support for it." << Abell, G., Annals of the NY Academy of Science, vol. 198, 8, 1972 >>

By the early 1970's, there was an additional impetus for astronomers to become involved with education: the employment picture in astronomy had swung to the opposite pole from the early 1960's. Now graduates of astronomy programs were having trouble finding research oriented jobs, although positions in education were somewhat more available. An "aims committee" chaired by Bart Bok reported to the Council at its December 1971 meeting <<AAS Council minutes, p. 1647ff>>, and included among its recommendations that:

* "Astronomy granting degree institutions should be encouraged to prepare their prospective graduates for careers in teaching, in which many of them will find themselves.
* We must help our PhD's and MA's...to develop ways in which they can apply for astronomically-oriented positions outside traditional colleges, universities, government laboratories and observatories... [They especially emphasized educational positions in smaller and junior colleges, planetaria, computer science, the Peace Corps, and even high school...]
* Students beginning graduate work in astronomy should be given as honest an evaluation of the job market as possible before they begin their graduate studies.
* The community should not enlarge and may even want to cut back on the production of PhD astronomers. The Heads of Astronomy Departments should be urged to begin thinking in terms of limiting the sizes of their graduate schools.

* This seems like a time in which we should urge the lower one third of each graduate group to terminate their graduate training with the Master's degree."

It was a pretty strong set of recommendations, and they were not widely put into effect, although a number of departments at the time did try to expand the placement of their graduates to non-traditional jobs. Eventually, new instruments and increases in federal funding improved the employment situation, although the issues would return in the 1990's, as we shall see.

The Task Group on Education in Astronomy

The late 1960's and early 1970's were an era of expanding popular interest in astronomy and the space program. The number of non-majors' college astronomy courses (and the number of students taking such courses) had begun to grow. New textbooks were being written and many popular-level books on astronomy attracted superb reviews in the mainstream media. Sensing the opportunities and challenges of this new era, the Board of the Astronomical Society of the Pacific had begun its new popular-level magazine *Mercury* in 1972 and had hired its first executive officer, whose responsibilities included increased emphasis on public outreach. The kind of leadership that would be needed to turn the attention of the members of the CEA toward this larger arena, however, was not forthcoming; a new, more informal structure was needed for the AAS.

Martin Schwarzschild, then President of the AAS, Don Wentzel, and Gerrit Verschuur (NRAO) worked out the principles of a new organization within the AAS, the Task Group on Education in Astronomy (TGEA), and obtained approval by the Council at the summer meeting in 1972. Unlike the CEA, which was a small group appointed by the Council, the TGEA was open to anyone who wanted to become active in the realm of astronomy education and outreach. Wentzel and Verschuur were named the first coordinators of the TGEA for a three-year term. They obtained a three-year grant from the Program on the Public Understanding of Science at NSF's Educational Programs Division and enjoyed the active support of the key officers of the AAS in their endeavors.

It was clear that if the TGEA's work were to have a significant national effect, it would depend not only on the small number of astronomers who did not see themselves as primarily research astronomers, but also on cooperation with other scientific societies and groups. After all, many departments of astronomy at research institutions did not consider educational work beyond the regular college courses as an activity that would further an astronomer’s career, and at least two of the original members of the TGEA were told this quite explicitly by senior colleagues. This was a time when Carl Sagan’s public activities (years before the *Cosmos* television series) were regarded skeptically by many astronomers and sometimes condemned as oversimplifying astronomy. Among those who became active in the TGEA were astronomers at museums and planetaria, as well as those teaching at institutions where research was not required.

Table 2 lists some of the projects undertaken by the TGEA, both under the initial leadership of Wentzel and Verschuur, and when Paul Knappenberger, of the Science Museum of Virginia, took over their position three years later. Note that many of these projects were initiated or undertaken by other organizations or institutions, but received encouragement, funding, support, or prestige through the involvement of the AAS. (TGEA reports appeared each year from 1972 through 1983 in the *Bulletin of the AAS,* and can be consulted by those who want more information on these projects.)

One of the most innovative of the TGEA-sponsored programs was organized by Von Del Chamberlain (then from the Abrams Planetarium, later with the National Air and Space Museum), to help rangers in the National Parks give evening "sky interpretation" programs. With NSF support, regional workshops were held in Tucson and at Goddard Space Flight Center, and four issues of a handbook full of activities and resources were published and distributed. Numerous astronomers visited parks as part of the program and provided sky interpretation and astronomy talks for both the park staff and the public. Even years later, astronomers volunteering to give a talk at one of the parks found the park management and rangers eager to use the opportunity. Upon Chamberlain's move to Hansen Planetarium, the program continued there at a reduced level.

Table 2: Some TGEA Projects 1972-1979

Project	Leaders
Astronomy in the National Parks (sky interpretation workshops and materials for park rangers)	Von del Chamberlain
Traveling Exhibit on Cosmology for Planetaria	Frank Jettner, Charles Smith
Four Brochures for High School Students on Topics at the Forefront of Astronomical Research	Gerrit Verschuur Paul Knappenberger
A Pilot Program of Radio Spots on Astronomical Developments (begun in Virginia)	Paul Knappenberger, Charles Smith
Listings of Astronomy Education Resources [began before TGEA]	Richard Berendzen David DeVorkin
Annotated List of Astronomy Lab Activities	Haym Kruglak
A Collection of Introductory Astronomy Course Syllabi	James Wertz
Workshops on Effective Astronomy Teaching and Student Reasoning Ability (which resulted in a published workbook)	Dennis Schatz, Andrew Fraknoi, R. Robert Robbins, Charles Smith, Paul Knappenberger
TGEA Newsletter (with eventual circulation of 560)	Don Wentzel, Gerrit Verschuur
Collections of Astronomy Activities for the Classroom	Dennis Sunal
Syndicated Newspaper Column on Astronomy (ASP & AAS)	Andrew Fraknoi
The Bok Prize for Outstanding High School Projects in Astronomy (begun by Boston U. and later taken over by the TGEA and ASP)	Michael Papagiannis
AAS Booth at Meetings of the Natl Sci Teach Assn	William Straka
Coordination with Other Organizations, including the American Association of Physics Teachers, American Chemical Society, AAAS, ASP, etc.	Many TGEA members

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Programs for Teachers at Many Levels

The TGEA's activities regarding college teaching were largely aimed at AAS members. A special TGEA session was held at the AAS meeting in August 1974 and included a panel discussion on how to train graduate students so that they would be ready to teach in small colleges. Within the next few years, several PhD astronomers accepted positions in small colleges, their jobs involving a heavier teaching load than faculty at research universities are used to. These astronomers, by the way, have been awarded a significant fraction of the AAS Small Research Grants (which give priority to smaller, less well-endowed institutions), allowing the Society to aid such faculty in keeping their research going despite the heavy teaching demands on them.

By this time, papers at AAS meetings were divided into subject categories, with education relegated to "Other Topics". Starting in 1974, education was made a separate abstract category. The first contributed papers session devoted to education attracted 11 papers in August 1974 and anywhere from 5 to 12 papers during the next five summer meetings of the AAS. (Summer meetings were emphasized since members whose primary interest was in teaching could more easily attend these meetings.) Several specialized programs of invited talks were organized in 1977 and 1978, and such invited and contributed sessions have continued at AAS meetings ever since, with the number of sessions and papers rising and falling with the interest level of the local organizing committees, Society vice presidents, and education committees or groups.

One of the most far-reaching initiatives of the TGEA was to begin programs to assist teachers (at community colleges and high schools) in doing a better job in teaching astronomy. This was the time when science educators were discovering the work of psychologist Jean Piaget and others concerning the stages through which the reasoning level of students progress (and the importance of using hands-on activities when planning instruction at all levels.) A TGEA session at the June 1976 AAS meeting led to a plan of conducting and publishing a workshop on effective teaching strategies for introductory astronomy. Dennis Schatz, then of the Lawrence Hall of Science at the University of California, Berkeley, was able to obtain NSF support for this project. Two workshops were offered (in 1977 and 1978) and the materials from them were judged to be sufficiently useful to warrant wider dissemination.

The publication that resulted, *Effective Astronomy Teaching and Student Reasoning Ability* by Dennis Schatz, Andrew Fraknoi, Robert Robbins, and Charles Smith (1978, Lawrence Hall of Science), was distributed to instructors around the country and became quite influential in the small world of astronomy education. Much of the later work in developing effective astronomy activities in such programs as Project STAR at the Harvard-Smithsonian Center for Astrophysics and Project ASTRO at the ASP drew inspiration from this pioneering work, led by Dennis Schatz during the days of the TGEA.

Two of the leaders of this first workshop, Dennis Schatz and Andrew Fraknoi (then of

Canada College and later of the ASP) went on to lead a series of workshops specifically for teachers in grades 3-12 around the country, mostly through the ASP but for other organizations as well (including the IAU and NSTA). These workshops, now called *The Universe in the Classroom,* are still continuing at ASP meetings today. When the AAS later introduced its own workshops for high school teachers, called *Astronomer for a Day,* the synergy continued with many of the materials and quite a few of the speakers coming from the ASP's workshops and publications.

Later, in 1984, the ASP and the AAS began a joint project to publish a newsletter on astronomy for teachers in grades 3-12, also called *The Universe in the Classroom.* Word about the free newsletter, edited by Fraknoi but written with the help of many members of both Societies, spread quickly and within a little more than a year, more than 10,000 requests for subscriptions had come in from around the U.S. and Canada. Scrambling to obtain the resources needed to meet the unexpectedly large demand, the ASP and AAS received support from the Canadian Astronomical Society, the International Planetarium Society, the Slipher Fund of the National Academy of Science, and several other groups. This newsletter is still being published, and is now translated into more than a dozen languages around the world (and then distributed locally.)

The AAS Press Officer

The Bok Committee Report in 1971 had strongly recommended that the Council appoint a public information officer. At the urging of the TGEA, the Council instituted the office of AAS Public Information Representative (PIR), later changed to Press Officer. Of all the innovations during the TGEA era, this was probably the most effective one in the long run. The PIR was charged with reaching the news media regarding exciting science at AAS meetings. The first PIR, appointed in 1973, was Kenneth L. Franklin of the Hayden Planetarium, briefly joined by William J. Kaufmann of the Griffith Observatory. They began to invite reporters to AAS meetings, to issue press releases for them about newsworthy work being discussed, and to arrange interviews with scientists during the course of the meeting.

The job was eventually combined with the work of the new Education Officer (see below) in 1979 and taken on by Harry Shipman, but by 1984 it was clear that the two volunteer jobs really needed separate individuals. Steve Maran of NASA's Goddard Space Flight Center has held the post ever since, becoming over the years one of the most effective disseminators of science information to the media in the country. Largely as a result of his efforts, the AAS is now widely held up by reporters as a model for how scientific societies should conduct their meetings to be of maximum utility to the media.

Just like many of the other educational activities, this project needed enormous persistence to take root. Astronomers had to learn how to communicate effectively with journalists and the journalists needed to be assured that newsworthy announcements would come from each AAS meeting. Very few journalists were sufficiently familiar with frontier science to appreciate both the significance and the inherent uncertainties of astronomical discoveries without assistance. The Press Officers had to teach both sides how to communicate better with each other; offering seminars for reporters on astronomical background and for astronomers on how to convey results in everyday terms. Today, the press conferences organized by Steve Maran in conjunction with AAS meetings can sometimes attract as many as a hundred journalists and regularly receive world-wide coverage in all the media.

Evolving Structure

During the first six years of the TGEA, astronomy education became a more "respectable" activity for professional astronomers. The TGEA certainly benefited from the change in astronomers' outlook, especially as the employment picture required a sober look at alternative job possibilities. At the same time, the TGEA contributed to this change, primarily by giving a new venue and visibility to those astronomers who, instead of or in addition to their research work, preferred to expand into educational spheres.

In 1975, when the TGEA's first charter needed to be renewed, the Council appointed a TGEA Advisory Committee, made up of more senior members of the Society and chaired by Owen Gingerich of Harvard. This advisory group eventually took on a life of its own, quite separate from the TGEA, and became known in the 1980's as the Education Advisory Board.

Encouraged by the work of the TGEA and feeling the need to relieve the Executive Officer of some of the work involved with educational activities as the office moved to Washington, the Council -- at the recommendation of the TGEA Advisory Committee -- in 1979 created the position of Education Officer, designed to be an *ex officio* member of the Council. This new AAS Officer would serve as press liaison, coordinate the work of the TGEA, and oversee the other ongoing educational programs of the Society, such as the Shapley lectures and responding to public inquiries. Secretarial support would be provided, but there would be no salary for the person in the position.

The first Education Officer was Harry Shipman, of the University of Delaware, who remained in the position for six years, acting at first as both education and public information coordinator for the Society. During his administration, the TGEA was still active, although in the 1980's its separate identity began to slip away as more and more of the AAS education program became consolidated in the Education Office. Regular reports of the Education Officer appear in both the *Bulletin of the AAS* and, later, in the *AAS Newsletter.*

In 1985, Charles Tolbert of the University of Virginia became the Education Officer and (as we have mentioned) Steve Maran assumed the newly separated position of Press Officer. It was under Tolbert's administration, in January 1988, that the AAS offered its first "Astronomer for a Day" workshop for high school science teachers. During the first workshop (in Austin), 60 Texas teachers participated in what was billed as "a research science meeting, but at a level that the teachers could understand. Some of what they heard was interesting, some esoteric, some exciting, and some dull (just like a real AAS session)." <<Tolbert, C. in AAS Annual Report for 1987, BAAS 20, 770, 1988>> In later years, the talks by research astronomers would be supplemented with talks and sessions by astronomy educators, and the teachers would be encouraged to attend some of the AAS sessions themselves.

Inspired by the success of the Education Officer concept for the AAS, the Division for Planetary Science appointed its own first Education Officer, Martha Hanner of JPL, in 1990. Since then, Linda French of Wheelock College, and Larry Lebofsky of the University of Arizona have held the post as well. In 1991, the Education Advisory Board formed a Working Group on Astronomy Education. The existence of such a group would allow AAS members to present an education paper as well as a research paper at the same Society meeting and would provide those members interested in education with a group identity within the AAS. So far, the Working Group, headed by Stephen Shawl of the University of Kansas, has sponsored a number of sessions at AAS meetings and an electronic newsmail on education issues (which is currently distributed to about 300 people, and can be consulted on the World Wide Web as well.)

The "Benefits to the Nation" Era

As the national budget deficits built up during the 1980's, the feeling of expansion and optimism that (rightly or wrongly) characterized much of that decade began to change into a concern for what would happen when the bills for all that spending would become due. As the 1990's began, astronomy, like many other fields, began to sense the Congressional reluctance to fund many domestic programs and the increasing demand that programs that were funded demonstrate their relevance to immediate national concerns. As the 1990's wore on, permanent positions for astronomers again became more difficult to obtain.

For several decades, the astronomical community had organized a "decadal survey" of the needs of the profession, presenting its research priorities in a united front to the federal funding agencies. The most recent such survey, looking forward to the 1990's, chaired by John Bahcall of the Institute for Advanced Study, included a special panel on astronomy's "benefits to the nation", with education assuming a significant role in its report. <<Trimble, V. Sky & Telescope, Nov. 1991, p. 485>> Astronomers may not be able to cure diseases, solve the energy crisis, or make the country more competitive with Asian economies, but, the report pointed out, the excitement of our exploration of the cosmos was a powerful tool in helping the nation's youngsters appreciate the value and effectiveness of the scientific method (and thus in helping to train a more technologically literate work force).

Many astronomers began to see that a modestly increased emphasis on astronomy education could be a politically and socially valuable step for the community to take. And, as in the 1970's, the education sector might offer the potential of additional jobs for graduates of astronomy programs who could not obtain research positions. Several candidates for AAS offices ran and won on platforms of increased attention to education.

Among the suggestions of the Bahcall survey report was that the AAS might consider instituting a prize for education (in addition to the various prizes it gave for research). As it happened, Bahcall was elected President of the AAS from 1990 to 1992 and, one day during his tenure, rode in a taxi with the President of the Annenberg Foundation. From their conversation was born the Annenberg Foundation Award, funded by the Foundation on a five year trial basis, to recognize achievement by an astronomer in the field of education and public outreach. The rules for the prize were recommended to the Council by the Education Advisory Board, and the first winner, in 1992, was, appropriately, Carl Sagan. Unlike the other AAS awards, this prize did not require its recipient to give an invited talk at an AAS meeting; still a way was found for each of the winners to speak at the meeting where the prize was awarded.

During the five years that the award was funded, however, the Annenberg Foundation changed presidents and priorities, and after the fifth award, there was no funding to continue the program and no active plan at the AAS to seek funding elsewhere. As we write this history, the award has been suspended indefinitely. One has to wonder whether the AAS Council would have accepted a new *research* prize without a permanent endowment or allowed it to disappear without involving more of the membership in efforts to find alternate funding?

In 1991, Mary Kay Hemenway of the University of Texas became the third AAS Education Officer and began to expand the activities of the Education Office significantly. She became active in a number of science education organizations, including the newly formed umbrella group called the Coalition for Earth Science Education. In 1992, the Society received funding from NSF for the supervision of the national program of Astronomy Research Experiences for Undergraduates. Plans were also made to apply for a substantial NSF grant to fund a national program of secondary-school "Teacher Resource Agents" in astronomy, modeled on a successful program in physics run by the American Association of Physics Teachers. This grant was received by the AAS and an extensive program of teacher training was undertaken between 1994 and 1996.

At the meeting of the Council in June 1993, Hemenway set off a fire-storm of discussion by requesting one-quarter time salary support for her work as Education Officer. Her request was occasioned in part by local issues of soft-money support for her at her own institution, but also by a growing sense that the level of activity in the Education Office was significantly greater than a volunteer should be asked to supervise. In response, President Sidney Wolff (NOAO) formed an Ad Hoc Committee, chaired by Council member Suzan Edwards of Smith College, to review education policy and operations within the AAS and recommend how the Council should deal with Hemenway's precedent-setting request.

The Education Policy Board

The Edwards Committee made its final report to the Council in June 1994, having engaged in vigorous discussion about the problems facing science education in the country at many levels and about the role the AAS should take in astronomy education. Their list of recommendations went much further than Hemenway's simple request: they advocated that the

Society should have a full-time paid Education Officer, together with an Education Policy Board that would function as the equivalent of the Society's Publications Board in the arena of education and public outreach.

Their report argued that "...the AAS needs to take a leadership role in defining the most effective strategy for the national community of astronomers to follow in order to maximize their contributions to enhancing the nation's literacy...and productivity in science. The AAS must also provide a framework and resource network to encourage and enable its members to become active and effective participants in furthering science education. Moreover, we need to ensure that these efforts ... engage the energies of the research community of astronomers. Not only can researchers expect to be increasingly called upon to justify how their efforts benefit society, but without the involvement of those who are at the forefront of acquiring new knowledge about the universe, the unhealthy separation of researchers from educators will remain a possible outcome." <<Report of the Edwards Committee, 1994>>

President Frank Shu then appointed an "Ad Hoc Committee on Educational Policy", chaired by Edwards and Stephen Strom of the University of Massachusetts, to consider the broad policy implications of the Edwards Committee recommendations, what was happening in science education at the national level, and what ways might be found to expand the AAS education effort in the context of these national changes. The new Committee, which soon became known as the Education Policy Board, began by considering the state of astronomy education and opportunities for AAS leadership at all levels (graduate, undergraduate, K-12, and public outreach.) It drafted, with some encouragement from the NSF, a broad proposal for an "Education Initiative in Astronomy".

At its January 1995 meeting, the Council (after much debate) approved a $10 increase in Society dues specifically earmarked to support education and public outreach activities. There were several arguments in favor of such a move: in an earlier survey of the AAS membership, increased work in education had been the only area for which a majority of members was willing to pay greater dues. And to fund an expensive education initiative, NSF would surely ask the AAS to shoulder a reasonable share of the costs. (With about 5,000 members, a $10 dues increase would still only generate about $50,000, not a lot of money considering the work that needed to be done; certainly not enough to fund a full-time, senior level Education Officer with appropriate travel funds and support staff.)

By the summer of 1995, however, the AAS was told that the Policy Board's ambitious NSF grant would not be funded and everyone had to go back to the drawing board. By late 1995, the Education Policy Board scaled down its proposal to focus solely on graduate education in astronomy, and soon received NSF funding for a series of meetings, discussions, and a report on this subject. These occurred throughout 1996 and many of the ideas suggested in earlier AAS reports (such as the Bok report of 1971) resurfaced independently. A final report is being submitted to the Council in summer of 1997, as we write.

In the meantime, in 1996, the Council approved a new structure for the AAS education effort. The older Education Advisory Board and the more recent Education Policy Board would be merged into a single Education Board, headed by an elected volunteer Education Officer. Bruce Partridge of Haverford College is assuming this role in 1997 and his group will be charged with continuing some of the policy initiatives and community-wide discussions begun by the Policy Board. In addition, the Society has hired a half-time paid Education Coordinator (Douglas Duncan of the University of Chicago) who will begin an active campaign to expand the educational activities of the Society in many areas. With a budget from the AAS limited essentially to the funds generated by the $10 dues increase, Duncan is having to scramble to find funds elsewhere and to leverage the efforts of other institutions and organizations, much as the TGEA did in the 1970's.

Is the current effort for more educational involvement by the AAS simply another crest of the waves of interest in education, which will subside as time goes on, or will the advent of a paid education staff member make a permanent institutional difference for education at the Society? We leave this question for future historians to ponder, noting only that the challenges facing our Society (and our society) at all levels of education remain formidable and worthy of our best efforts.

About the Authors:

Andrew Fraknoi is Chair of the Astronomy Department at Foothill College near San Francisco and an Educational Consultant for the Astronomical Society of the Pacific. He served as the Society's Executive Director for 14 years and edited *Mercury* magazine and *The Universe in the Classroom* newsletter. Currently, he is the Director of Project ASTRO, a program to link professional and amateur astronomers with 4th through 9th grade classrooms around the country. The author or co-author of 13 books on astronomy and astronomy education (including *Voyages Through the Universe,* an introductory astronomy textbook published by Saunders), Fraknoi appears regularly on local and national radio programs explaining astronomical developments. He is the recipient of the AAS Annenberg Foundation Prize and the ASP's Klumpke-Roberts Award; Asteroid 4859 has been named Asteroid Fraknoi to recognize his work in education and public outreach.

Donat Wentzel is Professor Emeritus in the Department of Astronomy at the University of Maryland, College Park. His research concerned the plasma physics of cosmic rays and the magnetohydrodynamics and plasma physics of the Sun, but he hopes his educational activities will actually be of longer and more lasting value. At Maryland, he helped develop an astronomy course which portrayed frontier science as a human activity and encouraged students learn to make judgments about data and its interpretations. For the AAS, he helped start the Task Group on Education in Astronomy and led or supported a wide range of programs in education through TGEA. He has also organized several International Schools for Young Astronomers through the International Astronomical Union and supervised the IAU Visiting Lecturers Program. Recently, he has led the Teaching for Astronomy Development program (mostly in Vietnam and Central America.)

White Paper for the AAS Education Task Force:

A Role that Fits the AAS like a Glove: Training Early Career Astronomers for Both Teaching and Outreach

Andrew Fraknoi
(Foothill College;
Former Executive Director: Astronomical Society of the Pacific)

For the last three years, the AAS has been offering the Ambassadors Program (see fuller description below) to help early-career members of the Society become better at outreach, and I would like suggest that this kind of training is very much the sort of thing the AAS should be doing. and should be doing more of.

I recently attended a topical research papers session in astrophysics, and it again made me realize how little of a typical astronomer's training is generally devoted to good communication skills and effective outreach. I saw astronomers mumbling (with no consciousness of the microphone), rushing through too much material, showing PowerPoint slides so crowded with numbers and words that they themselves had trouble reading it, and speaking with little real awareness of the audience (many of whose members were, as a result, energetically consulting their laptops, tablets, or phones.)

Yet many astronomers will, during their careers, be called upon to teach non-science majors, to speak to reporters or TV journalists, to give a public lecture, or to explain their work to a government official or important donor. To the degree that we can prepare AAS members to be effective in these roles, we are giving them life skills that will benefit not only them, but the entire astronomical community. (More and more, we are learning, both continued government funding and increased private funding will require scientists to be able to explain the public benefit of their work in an articulate way.)

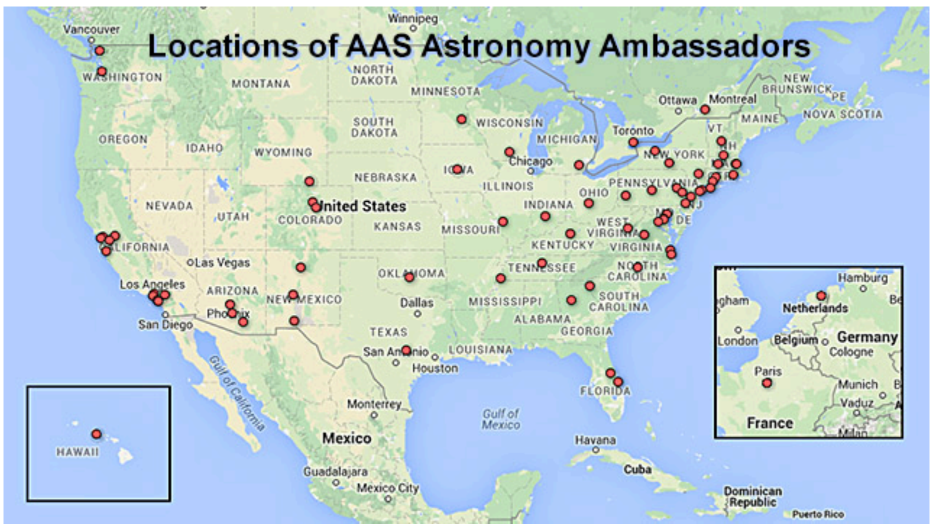
So far, the AAS Ambassadors have trained about 30 early-career members a year at one meeting a year. (The DPS had a short version at one of their meetings, as well.) May I suggest that we not only need to continue this program, so that more young people can be trained at the winter meetings, but we should consider expanding it to two meetings per year. Indeed, I hope that members of the Task Force might agree with the notion that such training should be available not only to early-career astronomers, but (perhaps for a fee) to ALL members of the AAS.

To the degree that this Task Force recommends that the AAS invest wisely in an education program that is funded by the Society from dues and journal and other income, I strongly hope that Ambassadors type outreach training will form one of the key pillars of that program.

ABOUT THE AAS AMBASSADORS PROGRAM (from AAS Web site, 2015)

More than 100 young AAS members (116 to be exact) have fanned out across the country to engage students, teachers, families, and the general public in the excitement of modern astronomy. These are our AAS Astronomy Ambassadors, graduates of intensive workshops held at the last three winter AAS meetings and last year's meeting of the AAS Division for Planetary Sciences.

The AAS Astronomy Ambassadors program was conceived by then-President Debra M. Elmegreen. At its core is a series of professional-development workshops and a community of practice designed to help improve early-career astronomers' ability to effectively communicate with students and the public. We asked our colleagues at the Astronomical Society of the Pacific (ASP) to develop and run the workshops and to set up and moderate the online community.



The workshop offers tips for finding existing programs and materials for astronomy outreach and helps participants learn how to identify specific opportunities in their own communities. Workshop sessions also assist young scientists in gaining a better understanding of how people learn and what makes outreach to nonscientists effective. Participants are provided with a large library of outreach activities and materials suitable for a range of venues and audiences. We call it the MOOSE, or Menu of Outreach Opportunities for Science Education.

Using infrastructure already developed for the ASP's Astronomy from the Ground Up (AFGU) program, we've built a forum dedicated to tools for, and communication among, AAS Astronomy Ambassadors. Participants are part of an online community that regularly exchanges ideas, resources, and experiences, not only with each other but also with their workshop trainers, both individually and in groups.

In the years since the first workshop, our Ambassadors have logged hundreds of outreach events at schools, summer camps, community centers, science museums, planetariums, nature centers, national and regional parks, fairs and festivals, science-institution open houses, and other venues. They have reached tens of thousands of people, ranging from preschoolers to senior citizens. It is clear from talking with the Ambassadors and reviewing their event logs that their activities are having a positive impact not only on their audiences, but also on themselves.

White Paper for AAS Education Task Force:

What Education and Outreach Work Should the AAS Be Engaged in?

Andrew Fraknoi *(Foothill College)*

Given the active involvement in astronomy education of NASA, NSF, the Astronomical Society of the Pacific (ASP) and the American Association of Physics Teachers (AAPT), among others, what specific role should the AAS take in the world of astronomy education and outreach? How should it use its limited resources and person-power to best effect?

In the past, the general guideline that we have used in determining where the Society should be active is that the AAS should do such things that best support its members in their education and outreach work. So what do the majority of AAS members do in this area? I would submit that (in the aggregate) they:

1. Teach Astro 101 to non-science majors
2. Teach upper level and graduate astronomy and physics courses
3. Give public talks and discuss their work with the media
4. Supervise/mentor graduate students, post-docs and others who may want or need to do 1 – 3 now or in the future, and are looking to their mentors for guidance.
5. (In fewer cases) Do research in astronomy education.

Relatively few AAS members have much to do with K-12 education, relatively few work in planetaria or science museums, and it is still true that relatively few do popular writing (magazine articles or books.) Those astronomy educators who work in planetaria and museums have their own professional groups (the International Planetarium Society and its regional affiliates; the Association of Science and Technology Centers.) Those doing K-12 work usually go to meetings and publish in the journals of the National Science Teachers' Association. And, in the past at least, training to work in the above areas has been carried out by the ASP.

If this analysis is correct, then it follows that the educational activities and webpages of the AAS should be devoted mainly to assisting members with the activities listed in 1-5 above. What activities should have priority?

a. Maintaining a current set of webpages that serve to refer members to the best current resources in astronomy education and outreach (essentially, serving as a clearinghouse for what already exists). This is already being done, in some measure, for outreach, through the MOOSE (https://aas.org/outreach/moose-menu-outreach-opportunities-science-education), but other parts of the education website have not been updated or organized in some time.

b. Offering training at AAS meetings (and division meetings) to help AAS members and potential AAS members in roles 1 – 5 above. Such training should have priority over other kinds of training before AAS meetings, and should, if necessary, get financial support from that part of the AAS budget that is devoted to education.
c. Offering ways that members engaged in such work can have sessions, give papers, and network at AAS meetings (this is already happening effectively.)
d. Provide methods of communication and publication for AAS members (and potential members) engaged in education. This could be in the form of list-serves, electronic newsletters, a journal, and/or other means.
e. When feasible, applying for and offering small-grant programs for AAS members who are engaged in such work, whether to support them locally or pay for their travel to AAS meetings (since such people rarely have significant grants that pay for travel.)
f. Supporting the training of AAS members and potential members in education and outreach at regional and local workshops, and providing information about such workshops to interested AAS members in some centralized and efficient way.
g. Making the AAS Jobs Register more inviting to educational jobs (perhaps by offering a subsidy to small or community colleges that cannot afford the current fee) and advertising more widely that such jobs will be welcome in the Jobs Register.

White Paper for the AAS Education Task Force:

Publishing Papers on Astronomy Education Research and Practice: An Ongoing Dilemma

Andrew Fraknoi *(Foothill College)*
E-mail: fraknoiandrew@fhda.edu

History

The modern era of astronomy education research essentially began with projects that probed learning in both the K-12 classroom and the planetarium in the 1960's. By the 1980's and 1990's, college courses in what is generally called "Astro 101" or introductory astronomy for non-science majors were also being examined by researchers. Papers resulting from this work were mostly published in journals reporting on science education in general.

The problem was that few of the *practitioners* of astronomy education read the journals in which this research was being published. And few of the *readers* of those journals engaged in much astronomy teaching. This meant that ideas or concerns that emerged from the research being done into the efficacy of astronomy teaching techniques did not – in most cases – reach those who would most have benefited from reading it.

There was no publication that tied together astronomy educators into a community, with common standards and a common literature, as *The Astrophysical Journal* and *Astronomical Journal* connected research astronomers, and *Sky & Telescope* and *Astronomy* connected serious amateur astronomers. As I discussed in an article in 2005 (http://www.astrosociety.org/pubs/mercury/34_05/epo.pdf), the increasing professionalization of the field of astronomy education and outreach really cried out for a journal of some kind.

For a number of years in the late 1980's, several of us who were concerned about the issue of where to publish astronomy education research papers and news formed various formal and informal committees and task groups, including one through the American Astronomical Society (AAS). We frequently discussed that, without a known and respected place to publish its work, a community has more trouble being treated as professional. This was certainly an issue with astronomy education researchers, both in the world of astronomy and the world of science education. Physics and geophysics, for example, both have journals where *educational research* can be published and easily accessed by professors who teach those subjects.

Furthermore, the lack of a commonly shared *repository* of established knowledge made it hard for new practitioners in astronomy education to get up to speed on what had already been done. Everyone was quick to agree that a journal and/or a newsletter could do the astronomy education community quite a bit of good. Where the discussions always foundered was the question of where the financial support for such enterprises might come from.

The Birth of *Astronomy Education Review*

By 1999 – 2000, I was the chair of the AAS task force on the need for an astronomy education research journal/magazine, but we were no closer to finding a way to publish one. Then, through a conversation with Sidney Wolff (SW), then the Director of the National Optical Astronomy Observatories (NOAO), a solution presented itself. SW was retiring as the observatory director and looking for a new project. Also, the expansion of the Internet made it possible to publish a new journal completely electronically. SW said that if I would write a detailed white paper and web outline of the journal's goals, sections, and requirements, she would try to persuade NOAO to use its infra-structure to program and publish the journal.

From that informal discussion, *Astronomy Education Review* (AER) was born. From the beginning, we planned for a publication that included more than just technical research papers. As in *Nature* and *Science*, we imagined that the research papers would be supplemented by editorials, news items and announcements, discussions of issues, resource reviews, and other items of interest to practicing educators. The costs involved in infrastructure, editing, and publishing electronically were born by the publisher and by a start-up grant we obtained from NASA.

Because the journal was new, and the community it could serve was scattered in many different kinds of institutions, I should note that I spent as much or more time doing active outreach about the journal (going to meetings, publishing articles, sending out email exploders, writing personal notes), as I did editing it. Without active "marketing" of a still new publication to its intended audience, it's difficult for it to gain traction. We did quite well, both in terms of eyeballs reached and papers published. I have compiled a complete subject index to AER and it is available at: https://aas.org/teach/subject-index-papers-astronomy-education-review-2001-2013

The End of *Astronomy Education Review*

The journal was published continuously for 12 volumes, ending in December 2013. However, when SW retired from NOAO, the Observatories asked to be released from providing infrastructure for the journal, and in 2009, the AAS agreed to take the journal over and, for the time being, continue to subsidize its costs from its journals fund. The journal was given to the American Institute of Physics to publish electronically, at considerably higher cost than before. The AAS also hired a new editor, Thomas Hockey of the University of Northern Iowa, who had edited books and publications in the history of astronomy for many years, but who had scant knowledge of the astronomy education research community and little desire/interest in doing outreach for the journal.

Under the AAS and the new editor, *AER* became more like an anorexic equivalent of *The Astronomical Journal,* in that it included, for the most part, only papers in astronomy education research, and little of the other material that we had originally envisioned would be of interest to educators and would serve to attract readers who were not themselves researchers. (After all, the community of astronomy education researchers is still quite small, while the community of astronomy educators is much larger.) Also, unfortunately, some of the ongoing efforts that had been made to publicize *AER* regularly and actively to solicit new contributions for its pages were neglected or discontinued under its new leadership.

By 2013, the number of published papers in *AER* had slowed and some observers felt that the contents of the journal were not as leading-edge in its field as the papers in other AAS journals were in theirs. That year, two reviews of *AER* were conducted, one by the AAS Education Board and the other by the AAS Publications Board. While the former review saw much potential in *AER* and strongly urged the Society to make changes to improve the journal, the latter recommended discontinuing it. After debate, the Council went with the recommendation of the Publications Board and ended the journal as of the end of 2013, promising only to keep its archives available on the web perpetually.

Thus we were back to the situation that astronomy education research had to be published in general science education research journals, which few practicing astronomy educators read. There have been some attempts to create a new journal in place of *AER,* but so far they have not been completely successful. The first, published by a single individual from his home, with no institutional support, has already died.

The Journal of Astronomy and Earth Sciences Education (JAESE), published by a for-profit and occasionally controversial publisher, is now on its third issue (http://www.cluteinstitute.com/journals/journal-of-astronomy-earth-sciences-education-jaese/). This journal also doesn't have the support of a respected national or international organization in our field; nor do its papers have DOI's (digital object identifiers) which are a kind of short-cut to enable users to find the papers from anywhere. (The AAS version of *AER* gave each paper or article from the journal's beginning a DOI.) JAESE sustains itself through submission fees and page charges, the total of which for a paper may be beyond the reach of some authors who do not have access to grant or institutional funds.

SPARK

Gina Brissenden, who is on your task force, can speak in greater detail to the history of SPARK, the newsletter on education which the AAS has been publishing sporadically, both in print and electronically. It was meant to be a newsletter that kept AAS members interested in education connected to each other and to events and projects in the field. In its later issues, it also featured non-refereed short articles about projects in education as described by their founders or leaders (a form of publishing that may not be as objective as we would wish, but certainly comes from the heart.)

When the AAS Education Board was considering changes to make in *AER,* one was to combine SPARK with *AER* in a single electronic publication. This would have returned AER to our original vision, of being more like *Science* or *Nature* (in that it combined news, reviews, and announcements with refereed research.) The idea was to produce a publication of interest to the much larger number of astronomy education practitioners and not just to the astronomy education researchers. To my mind, something of that nature is still what is most needed.

The Future

One of the issues the AAS Pub Board brought out, and the Council discussed, was that *AER* was not giving the Society enough of a bang for its buck. The number of contributors (of research papers) and the number of readers was far too low, given the high cost that AIP was charging. But my sense was that this was more a result of neglectful editing and marketing, than it was of a problem with the fundamental *concept* of such a journal.

Had the AAS Council gone with the recommendations of the Education Board and not the Pub Board at that fateful meeting, I (and others) would have been glad to join in the effort to resuscitate, revitalize, and renew *AER.* The key ways forward might have included:

1. Finding a publisher that would do *AER* electronically at a lower cost than AIP's very luxury-class approach. I suspect IOP or some other publisher would have found a way to do this.
2. Making it both a journal and a magazine for astronomy education (along the lines *Science* or *Nature)* and make sure it is an interesting publication. It could be a vehicle to discuss topics in education where professional disagreement is instructive, it could bring

news of jobs, grants, meetings, vehicles for cooperation, it could have featured reviews of educational materials, etc.

3. Finding an editor and some staff time to not just edit the journal, but to *market it* (at least at the beginning) in a tasteful way to its various natural audiences -- including astronomy instructors in grades 8-16, Astro 101 professors, EPO professionals (including those at NASA), planetarium and museum educators, astronomy text and popular-book authors, curriculum developers, etc.
4. Investigating sources of possible revenue (including grants for the set-up costs of the new version, modest page charges, donations by readers, a subscription fee for non-members, advertising, and deriving some (but not all) of its costs from the journals fund of the AAS.
5. One thought that the Ed Board had been discussing was the desire of the AAS to attract more members who were mostly educators and not researchers (including professors at small, state, and community colleges). Such an education journal/magazine would have been the natural recruiting tool for this audience.
6. Getting support or co-sponsorship from other Societies, including the Astronomical Society of the Pacific and the American Association of Physics Teachers (both of which investigated starting a journal when AER ended, but did not think they could do it alone.)

I hope the Task Force will urge the Council to re-open this discussion, which I think may have been closed prematurely. I believe I am not alone in thinking that there should be a place in the portfolio of the AAS for some sort of "publication" that helps tie together and further the interests of its many members engaged in astronomy education research, practice, and outreach.

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AAS Education task force white paper about education outreach to the Native American community, Katy Garmany, NOAO

With the current realization that astronomers have done badly in engaging with the native Hawaiian community, it appears that there is growing interest in outreach to Native Americans. While well intentioned, there are issues that arise which need to be acknowledged.

My experience with the Native American community comes from my interactions over the past 12 years with members of the Tohono O'odham nation, on whose land Kitt Peak is located. In my role in EPO at NOAO, I have worked in the schools, clubs, and taught astronomy at the community college located on the reservation. I have numerous friends on the reservation: I have regularly attended the annual fair, and was even asked to judge the parade one year. If I can offer anything, it is that every tribe is different, so I cannot generalize. But given that, I offer the following.

Few of us can possibly understand the problems faced by tribal members today. Cultural differences are vast and add to that a world where everyone has relatives involved in drug smuggling, where teenage mothers the norm, where schools always rank at the very bottom, and teachers from outside the community rarely stay more than a few years.

So any outreach project must begin by listening carefully to members of the native community for their input on what would help. Past efforts have often sown distrust: " You come seeking collaboration with us in order to win your grant, but once you have it, we don't see you any more" (ref B.Siquieros, in Garmany, 2013)

For example, does a particular tribe's culture forbid observing something, like an eclipse? Our EPO group learned that the Navajo do not believe one should do this, which pretty well shot down a well-meaning project! And is a tribe even willing to share that information with outsiders? The O'odham are not willing to share many aspects of their culture with us Mi:ligan: after many years, I now understand that historical O'odham culture enjoins people not to "count the stars". No wonder some of our dark sky projects aren't popular.

My personal recommendations:
Personal contact cannot be overemphasized: email isn't the way to develop relations!
If you want to learn what educational efforts will help a community, you will need to spend time in that community learning about them.

References:
Garmany, K., 2013, ASP Con. Series, "Communicating Science" vol 473, p. 73, "Suggestions from the Native American Community about Science/EPO Collaborations"

By Dr. Harold A. Geller

GEORGE MASON UNIVERSITY

4400 UNIVERSITY DRIVE • FAIRFAX, VIRGINIA • 22030-4444
10 May 2016

To Whom It May Concern:

This serves as my response to the AAS Education Task Force Call for White Papers. The approach I have taken is to note the state of education and public outreach in astronomy and compare today's state of affairs with that of a half century ago.

Sadly, I do not see many changes in the almost half century of astronomy to which I can bear witness. In fact, in certain arenas I see a slippage in the progress. I can still recall the problems that Carl Sagan had because he was willing to engage the public in conversations about astronomy over 40 years ago. The astronomy community did not take kindly to Sagan's approach to education and public outreach, and his position in the science community also suffered. I still recall the ridicule received by Sagan for his appearances on the Tonight Show with Johnny Carson (himself an avid amateur astronomer).

Thus, the issues that the Education Task Force itself should address can be separated into two major categories, that of the view of astronomy education and public outreach from within the astronomy community and the view from outside the community. A perspective to consider as part of the external community connectivity; is the view that the astronomy community has of the amateur astronomy community, including a myriad of astronomy clubs.

The AAS Education Task Force should promote the participation of astronomers in the education and public outreach venues including participation in amateur astronomy venues. I recall 40-50 years ago when public engagement by professionals was encouraged by agencies and the time spent out on talks was considered to be part of the professional job. Beginning in the 1980s, this accommodation by agencies was altered, and the time spent by professionals interfacing with the general public had to be taken as time off from the regular duties of the professional.

Collaboration between professionals and amateurs must be strong and professionals should not look down on the amateur astronomy community. Yes, there has been some friction, especially when amateurs literally compete with professionals for funding sources; but, cooperation will outweigh the competitive additions, at least in those venues where amateurs are sincere about their interest in the science, and not just their own self-indulgences.

I present here a summary of issues that I believe the AAS Education Task Force needs to address:

- How participation in education and public outreach is perceived within the community.
- How astronomers are perceived in the general public.

- How astronomy is perceived by the organized religions of the world.
- How astronomy is perceived by the other sciences.
- How education and public outreach is perceived by university administrators with respect to the tenure and promotion process.
- How to promote astronomy to the media; a 24/7 cycle between cable and broadcast television.
- How to reinstate the education and public outreach grant contract add-on, which was at one time encouraged and common, only to be denied by Congressional edict.

Possible actions for the AAS Education Task Force to recommend:

- Recommend that education and public outreach is part and parcel of any tenure and promotion process at all universities.
- Promote extensive exposure of professional astronomers to the general public.
- Sponsor a traveling astronomer program for education and public outreach via a venue of a Class A recreational vehicle outrigged for astronomy outreach, including an inflatable planetarium and portable observatory.
- Sponsor a volunteer program similar to the NASA JPL Solar System Ambassador program; whereby professional astronomers are pooled to participate in outreach to the public on an as requested basis.
- Promote astronomy in the halls of the United States Congress as well as the state legislatures of all 50 states. The American Association of University Professors (AAUP) has an active venue in this arena.
- Promote reinstatement of the Office of Technology Assessment in the U.S. Congress.
- Promote direct talks with religious organizations to quell anti-science sentiments.
- Promote the reinstatement of education and public outreach grant add-ons, which was at one time common, but now disallowed under new Congressional edict.

In conclusion, education and public outreach may be the most important component of the activities led by the American Astronomical Society. Its importance is not only tied to the future of the profession, but also to the future of the society at large. The earliest of human civilizations was well aware of its linkage to the universe within which we find ourselves. Today, we need to make certain that our own civilization realize its connectivity to the universe. If not, we may well find that the civilization lifetime of our own civilization will not be any longer than those civilizations that have come and gone before us.

I hope that the AAS Education Task Force will take these issues under advisement.

Sincerely,

Dr. Harold A. Geller
Observatory Director
Associate Professor
Physics and Astronomy
College of Science

Small Telescope Research Communities of Practice

American Astronomical Society's 228th Meeting, Hilton Bayfront, San Diego, California
Meeting-in-a-Meeting Special Sessions, Monday/Tuesday June 13/14, 2016
Wrap-up Moderator: Virginia Trimble, University of California, Irvine
Organizer: Russell Genet, California Polytechnic State University
russmgenet@aol.com (805) 438-3305

I. Pro-Am Communities of Practice Monday, 13 June,10:00am-11:30am

Communities of practice are natural, usually informal groups of people that work together. Experienced members teach new members the "ropes." This vital human activity has been studied in depth by social learning theorists such as Etienne Wenger, whose 1998 book, *Communities of Practice: Learning, Meaning, and Identity,* defined the field. As Wenger suggested in his classic book, "Learning is a matter of engagement: it depends on opportunities to contribute actively to the practices of communities that we value and that value us, to integrate their enterprises into our understanding of the world, and to make creative use of their respective repertoires." There are, in astronomy, many communities of practice. Some communities are centered on observing faint objects with large telescopes and analyzing the results. These communities, led by seasoned astronomers, include graduate students and post-docs who are learning the ropes. Other astronomical communities of practice are centered on observing brighter objects with smaller telescopes. These communities often stress professional-amateur (pro-am) cooperative research. They take advantage of the large number of smaller telescopes and observers. Examples of such pro-am communities of practice include variable star observers (ably organized by the American Association of Variable Star Observers), and a wide range of pro-am research fostered by the Society for Astronomical Sciences

Speakers

Russ Genet, California Polytechnic State University: Introduction to Pro-Am and Student-Centered Astronomical Research Communities of Practice

Stella Kafka, American Association of Variable Star Observers: The American Association of Variable Star Observers as a Pro-Am Community of Practice

Bob Buchheim, Society for Astronomical Sciences, Pro-Am Cooperation in Small-Telescope Astronomical Research

Round-Table Discussion by the Speakers

Moderator, Stella Kafka, American Association of Variable Star Observers

II. Student-Centered Communities of Practice Monday, 13 June, 2:00pm-3:30pm

For students who would like to become scientists, joining a community of practice early in their educational career is beneficial. A number colleges and universities offer well-developed undergraduate astronomical research programs. There are also a number of summer research programs for undergraduate astronomy students, such as the NSF-sponsored Research Experience for Undergraduates (REU). High school students are also participating in organized, student-centered astronomical research programs. A good example is the now decade-long Astronomy Research Seminar offered by Cuesta College in San Luis Obispo, California. Well over 100 students, composed primarily of high school juniors and seniors, have been coauthors of several dozen published papers. Being published researchers has frequently boosted these students' educational careers with admissions to choice schools, often with scholarships. This seminar was recently expanded to serve multiple schools with a volunteer assistant instructor at each school. The students meet regularly with their assistant instructor and also meet online with other teams and the seminar's overall instructor. This seminar features a textbook, self-paced learning units, and a website sponsored by the Institute for Student Astronomical Research. Each team is required to plan a project, obtain observations (either locally or via a remote robotic telescope), analyze their data, write a paper, submit it for external review and publication, and present their results.

Speakers

John Kenney, Concordia University: Merits of Undergraduate and High School Research

Jolyon Johnson, University of Washington: Evolution of an Astronomy Research Seminar for High School and Community College Students

Pat Boyce and Grady Boyce, Boyce Research Initiative: High School Astronomical Research at the Army and Navy Academy

Round-Table Discussion by the Speakers

Moderator, Jolyon Johnson, University of Washington

III. Research Areas Suitable for Small Telescopes Tuesday, 14 June, 10:00am-11:30am

Advances in low cost but increasingly powerful instrumentation, computers, and software have greatly increased the capabilities of smaller telescopes. Close visual binary star astronomy provides a good example of how such advances have allowed observers, at very low cost, to obtain outstanding results. Visual double stars with separations below the seeing limit typically require speckle interferometry observations with high-speed, low-noise, electron-multiplying emCCD cameras costing well over $10,000. Recently, however, low-noise CMOS cameras (such as the ZWO ASI290MM) have become available which cost under $1000 and perform nearly as well. There are many other areas that are well suited to smaller telescope research, including time series photometry of eclipsing binaries, variable stars, exoplanet transits, and asteroids, not to mention asteroid and lunar occultations, as well as stellar polarimetry. Low resolution spectroscopy on smaller telescopes works well for both stellar spectral classification and following variable stars. These many research areas have not only benefited from camera and computer advances, but increasingly from the automation of smaller telescopes and observatories.

Speakers

David Rowe, PlaneWave Instruments: Advances in Small-Telescope Speckle Interferometry

Dominic Ludovic, University of Iowa: A Low Cost Grism Spectrometer for Small Telescopes

Virginia Trimble, University of California, Irvine: Second to Last Thoughts

Wrap-up Round-Table Discussion by the Speakers

Moderator, Virginia Trimble, University of California, Irvine.

The Popularization of Astronomy through Books and Movies

Nick Gorkavyi (301-867-6334; NASA/GSFC/SSAI; nick.gorkavyi@nasa.gov)

Prof. Anne Simon (UMD), the biologist and the science adviser for the television series "The X-Files", wrote: “A major issue facing the US is the insufficient number of young, diverse individuals choosing STEM majors in college. This problem is exacerbated by unflattering, stereotypic images of scientists in the media, which dissuade promising students from considering STEM careers”. The National Academy of Sciences recently established the "Science and Entertainment Exchange" to help foster collaborations between the entertainment industry and working scientists. NASA decided to assist the filmmakers with depicting the science and technology in “The Martian” since it saw potential in promoting space exploration. NASA and the wider scientific community anticipated the film “The Martian” as a way to publicize a science and astronomy.

I wrote the Sci-Fi book "AstroNika" to inspire teenagers with the science, in particular astronomy, physics and biology. A quarter of this book can be considered as a popular science. The book was highly successful and sparked a lot of interest particularly among teenagers. First published in 2008 (in Russian) the book had 4 editions since then and more than 45 000 copies were sold. More editions are coming soon. I have received several letters from the readers that my book inspired children to pursue STEM careers. For example, one of my readers was motivated to study astronomy in Missouri University.

"AstroNika" book encouraged me to start the following projects:

1. Popular science book series with characters from "AstroNika". These are "bed-time" stories for children 7-12 about the great scientists such as Ptolemy, Newton, Einstein and many others. Four such books have been published: “Stellar Vitamin” (2012), “Celestial Mechanics” (2013), “Creators Era” (2014), “Space detectives” (2015) – see Fig1. All books were very successful with the third edition coming this year. I am currently working on a fifth book. The total amount of the scientific stories will be 100. The each book has color and black-white illustrations (Fig 2). NASA scientist Dr. John Mather, Nobel laureate and my former scientific adviser at NRC/NAS position, has already supported my book with the words to my readers (see Fig 1).

2. The screenplay based on "AstroNika" was written with support of readers.

All my books are international by spirit and my protagonists live on the Moon (and on my asteroid 4654). Recently "AstroNika" and the screenplay were translated to English. I started looking for a literary agent for publishing my books in the US and for movie production. I understand that for literary agents and Hollywood producers this project will be one of thousands.
But astronomical community will greatly benefit from the books and the movie that promotes astronomers and space sciences. I hope that the AAS support my books and screenplay by next points:

1. The AAS can help with finding a publisher for the translation and publication of the book with 33 stories about the great astronomers - or the AAS can give the grant 10K for translation of the book “33 Astronomical Stories” and will help with finding a publisher for the publication only. This book can be first in “The AAS library for children”.
2. The AAS can express interest to the Sci-Fi movie for YA, based on novel “AstroNika”. The AAS’ support does not imply monetary aid but can include the public announcement, recommendations for producers etc. Electronic versions of the “AstroNika” and the screenplay can be provided to the AAS for consideration.

Fig 1. The book “Space detectives” (2015) with the words from John Mather. The back cover shows the popular science books by Nick Gorkavyi published in 2012-2014.

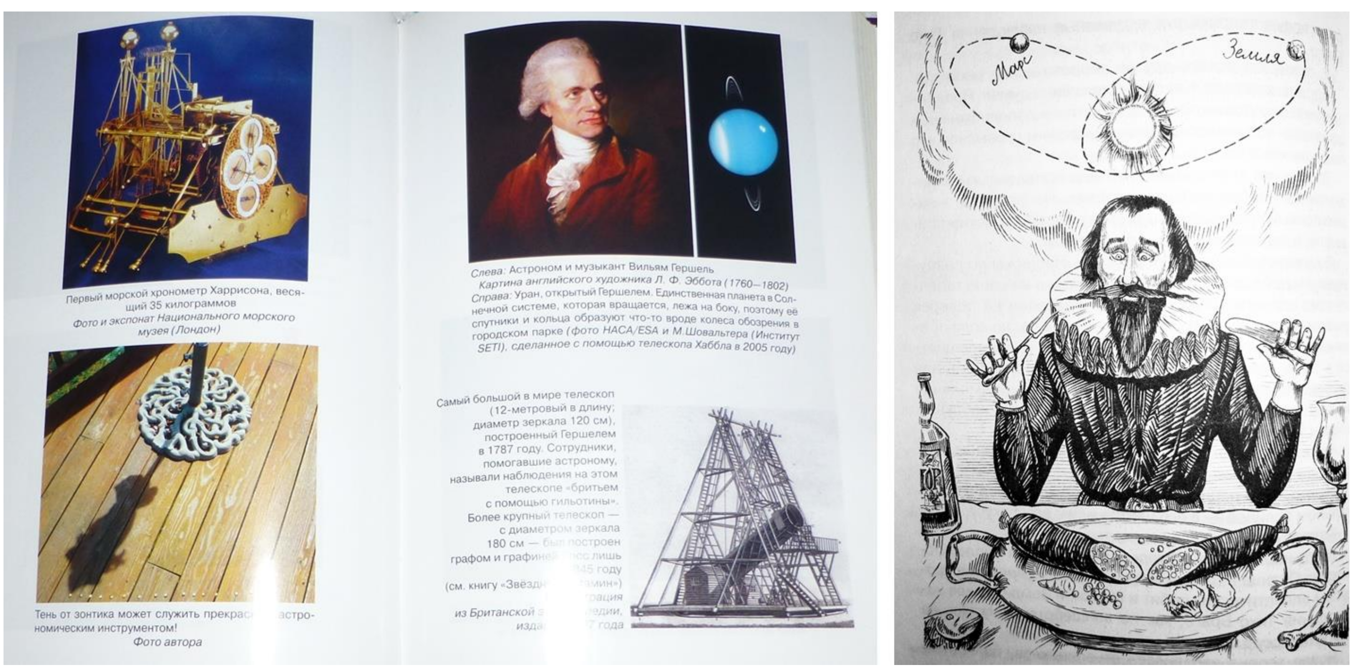

Fig 2. The each book has 16 pages of color illustrations (left) and 32 pages of black-white pictures (right: Kepler, illustration by Kirill Garin). The samples from “Celestial mechanics” (2013).

Astronomy Education at Small Institutions

Nicole Gugliucci, Saint Anselm College, Manchester, NH 03102, ngugliucci@anselm.edu
Hugh Crowl, Bennington College, Bennington, VT 05201, hcrowl@bennington.edu
Joshua Tan, Pontificia Universidad Católica de Chile, Santiago, Chile jschroed@astro.puc.cl
Joseph Ribaudo, Utica College, Utica, NY 13502, jsribaud@utica.edu
John Bochanski, Rider University, Lawrenceville, NJ 08648 jbochanski@rider.edu
Tim Hamilton, Shawnee State University, Portsmouth, OH 45662, thamilton@shawnee.edu
Will Clarkson, University of Michigan-Dearborn, 4901 Evergreen Road, MI 48128, wiclarks@umich.edu

1. Introduction

Small colleges and universities in the United States (often defined as institutions with less than 5000 students[1]) are an important part of the US academic landscape. Astronomers who work at such institutions typically do so in the context of physics departments or even broader science departments. They are often the only astronomer or one of a very few number employed by the institution. As such, much of the subject-support these astronomers require must come from without, while the success of the the entire school's astronomy program hinges on that single individual. We ask the AAS Education Task Force to support the programs and initiatives described in this paper that aid astronomers at small institutions to continue and enhance their robust teaching and research programs.

Small colleges and universities have historically been institutions that serve a wide range people. Many small institutions teach underserved populations, and, as such, support for astronomy pedagogy and research at small institutions can serve the goal of greater equity and inclusion in astronomy and across STEM generally (as many astronomy students as undergraduates will go on to other technical fields after graduation). We encourage astronomers at small institutions to be especially mindful of ways that they can better support the goals of increasing the number of underrepresented minorities in their programs and call upon the AAS to provide the support and resources necessary to fulfil such goals[2,3].

2. Resources and best practices for small classes

Small colleges provide a unique opportunity to develop teaching practices that work well, and track those that don't work well, for small classes. A typical introductory astronomy class may be very popular at a small college but still have an enrollment under 30 students. This is a very different environment from the several-hundred student courses taught at large universities.

[1] http://www.collegedata.com/cs/content/content_choosearticle_tmpl.jhtml?articleId=10006
[2] Bug, Amy. "Has Feminism Changed Physics?" Signs: Gender and Science: New Issues 28.3 (2003): 881-899.
[3] Whitten, Barbara."(Baby) Steps Towards Feminist Physics." Journal of Women and Minorities in Science and Engineering 18.2 (2012): 115-134.

Though many of the same techniques (lecture tutorials, think pair share, etc) can be effective at smaller institutions, their use should be modified to make best use of the size of the classroom. In fact, it can be easier to try and implement new curricular designs and techniques in smaller classes, making small college astronomy courses an excellent proving ground and space for innovation. We encourage the AAS Education task force to encourage further development and knowledge sharing among astronomers teaching small sections of introductory college courses.

3. Support for low-enrollment upper-level astronomy courses

Upper-level courses at small colleges can face institutional pressure due to minimum enrollment criteria. A large introductory class can have as few as 30 students and upper-level courses may only have half a dozen. In locations where multiple institutions exist within driving distance of each other, options should be explored for class-sharing. Other options that may be explored are distance learning opportunities using teleconference and networking technology. These options would require significant discussion at the institutional level, and support from the AAS Education community would aid astronomers in bringing these issues to their institutions.

4. Resources and best practices for small or developing observatories

Small colleges typically do not have the resources to develop large instruments and observing programs. Such institutions may be served by partnerships with local observatories, larger universities, or by collaborating with nearby small institutions as discussed in Section 2. Although there are a growing number of opportunities for remote observing such as through the University of North Carolina's Skynet[4], students can also benefit from working on small-scale, hands-on projects that both benefit the students' learning and, over time, build up the capabilities of an institution's astronomy program. Examples of such projects include small optical telescopes used in long-term monitoring projects and Small Radio Telescopes[5]. We encourage further development of such projects with support from astronomers at institutions with successful programs and the AAS as a facilitator for such interactions, as it has with the new Kentucky-Area division of the AAS.

For a modest installation cost (on the order of \$10,000 to \$100,000), small astronomy programs in even heavily light-polluted environments can build optical observatories to function as teaching and research opportunities for students as well as excellent venues for conducting public outreach. Minimally, decent optics, a stable mount with precise pointing capabilities, and a fan cooled CCD with a filter set are sufficient to allow for extremely important auxiliary work that has, in the past, been part of key observations for a number of breakthrough research

[4] https://skynet.unc.edu/
[5] http://www.haystack.mit.edu/edu/undergrad/srt/

projects[6]. Such work includes monitoring variable stars, supernovae, novae, and microlensing events[7,8].

Note that hardware and site requirements are dramatically less stringent than even ten years ago, thanks to improvements in the availability and power of publicly available software tools and catalogs against which small-telescope observations can be calibrated. An example might be a campus observatory in an urban area, for which pointing drift on the order of one pixel per minute prevents long exposures. In a traditional long-exposure mode of observation (to reach faint objects, say), such a facility would be difficult to use, but software tools allow site- and hardware limitations to be circumvented. A valuable learning process in practical problem-solving, is for students to use standard astronomical software (like Starlink in conjunction with IRAF, or AstroImageJ) to produce high-quality absolutely-calibrated photometry (including image-stacking, astrometric calibration, matching to standard catalogs, and photometric transformation). A second example is pointing calibration in the face of hardware limitations; the Astrometry.net webservice is sufficiently robust and fast that observations can be calibrated on an absolute sense, during the observation run, without any pointing information attached to the input images at all.[9] This is particularly useful for campuses with older hardware in which pointing information is unavailable to the camera at the time of observation.

We encourage the AAS to start, support, and publicize funding programs that are geared towards promoting the construction and, crucially, maintenance (both in terms of physical maintenance and in terms of salary supplements/replacements and research stipends for students) of such observatories.

5. Support and advising for students in such schools looking towards graduate school in astronomy

Students choose to go to small colleges and universities for a variety of reasons. However, such students may be at a disadvantage when looking to pursue graduate work in astronomy. We applaud the AAS's role in downplaying the importance of the Physics GRE in graduate school acceptance[10], as enrollment in smaller institutions without graduate programs have been shown to correlate with lower scores[11]. Other factors are in play, such as availability of research opportunities at the home institution, competition for research opportunities at larger institutions, such as through the NSF REU programs, availability of funds to travel to conferences, and the strength of their mentors' networks. We think AAS should encourage networking, provide limited

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[6] E.g., the discovery of SN 2014J during undergraduate teaching session at University College, London http://www.ucl.ac.uk/mathematical-physical-sciences/news-events/maps-news-publication/maps1405

[7] See https://www.aavso.org/ for the network of American variable star observers

[8] See http://cbastro.org/ for a small telescope network for cataclysmic variable montoring

[9] See http://astrometry.net/ , also Lang et al. 2010 AJ 139, 5, p1782

[10] https://aas.org/posts/news/2015/12/presidents-column-rethinking-role-gre

[11] http://scitation.aip.org/content/aapt/journal/ajp/59/5/10.1119/1.16517

travel support, and support research opportunities for these students in order to ensure that the astronomy profession can draw from the widest pool of applicants possible.

6. Support for Undergraduate Research in Astronomy

Research opportunities are one of the most valuable experiences for students learning science. Because of the smaller number of astronomy faculty at most small institutions, the breadth of research opportunities are limited. Opportunities such as NSF-funded REU programs and research coordination between nearby institutions can expose students to wider fields of research. We encourage the AAS to continue to develop research collaboration opportunities among small institutions.

Students from small colleges and universities benefit from being exposed to professional-level observing opportunities, whether through remote observing or through traditional observing runs. Such research experiences can happen in consort with a research program quite effectively. One of the major impediments for doing this is a lack of funding, as faculty members at smaller institutions often do not have research budgets large enough to pay for the expenses of students. One possible pathway to address the challenges associated with developing and maintaining diverse research experiences at small colleges has been pioneered by the Undergraduate ALFALFA Team (UAT) over the last decade[12]. The programs led by the UAT have established a training and development model that provides research experience for both students and faculty from smaller schools[13]. The UAT is a prime example of how student-centered research programs in astronomy can make substantive and lasting science contributions[14] while also highlighting the substantive and lasting educational impact made possible when observatories are kept open that are at the risk of closing. We encourage the AAS to support the funded operation of one-meter class and small telescopes at the National Observatories such as Kitt Peak and the continued operations at Arecibo Radio Observatory, both of which have come under increasing budgetary pressure and threats of closure[15,16], with an eye towards expanding the pedagogical resources that come with exposing students to astronomical research. We encourage the AAS Education task force to consider supporting extant programs that are open to small colleges and universities and as well as aid in developing similar kinds of programs that would give opportunities to undergraduate students who might not otherwise get the exposure to the research lifestyle in astrophysics. New regional groups modeled on the AAS Kentucky-Area division can provide institutional sharing of research equipment, facilities, and in some cases advisors.

An additional initiative to which a society with national reach like the AAS can contribute, is explicit matching of the skills learned by students in undergraduate research to the typical skills

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[12] http://egg.astro.cornell.edu/alfalfa/ugrad/index.php
[13] E.g., http://www.stlawu.edu/physics/arecibo-observatory
[14] http://egg.astro.cornell.edu/alfalfa/pubs.php
[15] http://www.noao.edu/currents/201110.html
[16] http://phenomena.nationalgeographic.com/2016/06/04/uncertain-future-for-earths-biggest-telescope/

in demand by non-academic employers. With a significant portion of small-college students choosing their path through higher education from a vocational perspective, clear and detailed exposition of the employable skills acquired by research students, would help students with an interest in astronomy to learn which skills they will develop that will help them after they graduate. In addition, such a resource would help students who have conducted astronomical research as part of their undergraduate experience, to communicate this clearly in their application materials for employment (inside or outside academia). The AAS could generate a document (or occasionally-updated website) with a ranked list of employable skills and specific language that might be used to highlight these skills in a resumé.[17]

7. Keeping lively connections with astronomers at other institutions

Astronomers at small institutions may be the only astronomer in their school or even geographical area, which can limit collaborative opportunities. To this point, regional astronomy societies and consortia have been successful at building community and networks among small colleges and the faculty that work there[18,19]. For example, the Astronomical Society of New York (ASNY) boasts over 15 member institutions that focus primarily on undergraduate education and the annual fall meeting of ASNY serves as an opportunity for many undergraduates at small colleges to attend and present work at their first science or astronomy meeting. However, astronomers working in a new area will often be unaware of the resources and support structures already in place - highlighting the need for increased communication and publicity as to where astronomers can go to obtain relevant information.

At many small liberal arts schools, Study Abroad programs have become an increasingly popular ways to expose students to a broader range of educational opportunities. Traditionally, STEM fields have not been as involved in such programs as much as the humanities or social sciences, but the international reach of astrophysics in the age of Big Astronomy provides a great opportunity for students to become engaged in astrophysics research around the world. Exchange programs between astronomers in the United States and astronomers in the major hotspots for astronomical research are one way to foster such connections. These opportunities are presently very institution-specific, but we encourage the AAS to provide material and financial support for astronomers at small institutions who may be interested in building such programs.

A myriad of online tools exist to mitigate such isolation and encourage networking over long distances. A new Facebook group, “Astronomers in Small Places” has been founded as an offshoot of the main “Astronomers” group to encourage astronomers facing similar challenges and opportunities at small institutions to discuss these issues. We propose that these discussions should be encouraged at face-to-face meetings of the AAS with an option for

[17] For example, undergraduate astronomy research often includes development of several high-demand data science skills; http://www.datanami.com/2016/01/07/what-data-science-skills-employers-want-now/
[18] http://www2.newpaltz.edu/~bartha/ASNY/telescope.html
[19] http://astro.swarthmore.edu/knac/

remote participation. We also propose the AAS maintain a database of the regional college and university astronomy groups and to provide support and infrastructure needed to establish regional societies and consortia throughout the country. We think that the astronomical community in general will be enriched through such opportunities and in keeping close contact with astronomers at a wide variety of institutions.

Education Task Force White Paper

David J. Helfand
Columbia University

The mission of the AAS is to "enhance and ***share*** humanity's scientific understanding of the Universe" (emphasis added). "Enhancing" includes the research we do, the public policy advocacy necessary to support that research, and the development of the next generation of astronomers. "Sharing" includes our professional communications (journals and meetings) and, the purview of this Task Force, education and public outreach. As we proceed, we should keep in mind the distinctions as well as the synergies behind "enhance and share" and, as Charles admonished us in our first meeting, focus on what the AAS — our society of *professional* astronomers — can and should do best.

My list would be as follows; it is not meant to be exhaustive and it is, as I said, *my* list. I think our first task is to generate a consensus list so we can apportion work and get started.

1. Graduate Education: Twenty years ago, an AAS Task Force wrote an excellent report on graduate education in our field (*https://aas.org/archives/BAAS/v29n5/edrpt.html*). It was almost uniformly ignored. Recently, the American Chemical Society wrote an excellent report on graduate education (and another on postdocs in their field); I don't know whether or not it suffered a similar fate. While I think some Astronomy departments, as least, have pulled their heads at least part way our of the sand in the past twenty years, others have not. Whether or not it is worth tackling the issues of admissions (the GRE debate), diversity, an expansive definition of graduate education (including public speaking, writing, statistics and data mining, coding, ethics, etc.), support for non-traditional tracks and careers, transparency of program results, etc. is unclear to me.

2. Undergraduate majors education: This affects several hundred students a year, and the diversity of approaches and programs currently extant seems to need little help. The link with SPS obviates, in my view, a need for an AAS-sponsored undergrad society. We have an award for good textbooks, and we are engaged in an e-publishing venture. I don't think there is much to worry about here.

3. Undergraduate non-majors education: This affects several hundred thousand students a year, plays a big role in the lives of many of our members, and, given the twin (and somewhat contradictory) notions of astronomy as a "gateway science" and astronomy as "the last science course many undergrads take in their lives", deserves considerable attention. I have three subcategories here:

a) new faculty training: We should examine the AAPT new faculty workshops carefully and decide whether or not they are serving new astronomy faculty well; are we being well-served or could we have a stronger voice in projecting leadership in STEM education if we did it ourselves. We should also examine the workshops we are providing at our meetings with an eye toward recommending enhancements and/or adjustments if necessary.

b) workshops on unfamiliar topics: Consider providing continuing education opportunities for members to learn about things they may have little or no background in (climate change (as the Sustainability Committee has done recently), astrobiology, teaching quantitative reasoning skills, etc.) but are becoming growing parts of of astronomy 101 classes.

c) active learning materials: This is the item I find to have the highest priority despite our repeated failures to achieve it and all the technical, legal, and ego problems it comes with. I believe it would be a great service to the thousands of members who teach 101 classes if the Society were to create a curated, constantly updated set of active learning materials (computer simulations/games, hands-on exercises, demonstrations, etc.) covering the range of topics typically taught in such courses.

4. Public Education and Outreach: Things to consider include

a) Review the Ambassadors program for effectiveness and impact.

b) Review the Shapley program for effectiveness and impact.

c) Review any other ongoing programs in this area; look for gaps to be filled.

d) Consider instituting a service, perhaps linked with AAS Nova, that provides brief background synopses for predictable upcoming events (conjunctions, meteor showers, eclipses, spacecraft landings, etc.) and for newsworthy discoveries that our members may be contacted about by the media for comment.

e) In light of a possible upcoming Council decision to institute an “amateur” membership category, consider what services (certificate programs, etc.), programming at meetings, and other activities we might offer to attract and support such members and enlist them in our mission.

White Paper for the Implementation of Educations Endeavors for the American Astronomical Society – submitted by Eric Hintz of Brigham Young University

It is interesting that a few months before the call for white papers came out from the AAS education committee, I have begun working on some ideas for educational activities at Brigham Young University. Some of these ideas would clearly have a broader impact than just one school. It had been suggested that perhaps a couple of white papers on different topics might be the best approach for a submission. However after much consideration I find that all the information is so interwoven that it should be discussed in a single document.

Just as a starting point I want to list some of the educational activities occurring at BYU. This is not to brag, but to provide background of why I'm thinking about how the AAS could use its influence and membership to help promote these kinds of efforts throughout the country. The activities clearly cover a wide range, as is also talked about in the call for white papers.

1) BYU Public outreach
    a. AstroFest each May. Completely free. Astronomy activities, planetarium shows, physics and engineering demos, paper rockets, etc. (approximately 1000-3000 people per year)
    b. Boy Scouts of American Merit Badge Pow Wow – twice a year. Use the planetarium to teach the astronomy merit badge (160 scouts per year)
    c. Weekly public planetarium shows and free observation deck, including one research telescope
    d. Other planetarium shows for school, family, or youth groups
    e. BYU Astronomical Society (the astronomy club)
    f. Introductory descriptive astronomy class
2) Preparing K-12 teachers and preparing graduate students to teach as faculty members
    a. BYU has one of the largest high school physics teacher programs in the country
    b. We also have programs with geology for junior high earth and space science teaching
    c. Many of these undergraduate students take the astronomy minor (to help with certification)
    d. Graduate student oversite of planetarium as assistant director
3) Education in a Planetarium (AER research efforts)
    a. We are very interested in how to effectively teach in the very tough environment of a planetarium. We have published a study of how students learn constellations from the 9^{th} grade through introductory college astronomy class
    b. Testing other planetarium teaching methods for introductory astronomy classes
    c. Major effort to understand deaf education in planetariums and other tough environments using head-mounted displays to provide ASL. Wherever the student is looking in the dome there is the signer.
    d. Study the impact of mentored research (18 years of required senior thesis to draw on)
4) Preparations for different majors
    a. Observational astronomy techniques class (required for astronomy minor). Contains many non-majors.
    b. Requirement for all Physics and Astronomy undergraduate majors to do a senior thesis. This leads many students to AAS meetings.
    c. We've been bringing undergraduates to AAS meetings for close to 25 years. Even before it was allowed.
    d. More students from other departments interested in astronomy research. At this point I have a mechanical engineering major, a philosophy major, and an Earth/Space Science teaching major doing publication quality research with me. Those are in addition to my traditional astronomy

majors. My teaching major presented her results at the January AAS meeting and will be a co-author on an upcoming publication. Many of these students come from the introductory classes.

Proposals:

1) Faculty teacher preparation – Work with American Association of Physics Teachers

Perhaps one of most intimidating things for a new faculty member is preparing for that first-class. Quite often this is not something that one has been trained for through the normal graduate student, post-doctoral experience. While some graduate students find opportunities to teach, perhaps of the nearby smaller university or college, this is not the normal case. Therefore, many new faculty are left to develop their teaching skills on their own. With years of experience teaching descriptive astronomy I have found that many of our best majors came to the major because of their experience in a descriptive astronomy class. For others this might be their only experience with science during their undergraduate years. If they have a good experience these could be future donors or supporters of science when government decisions are made. Therefore in all cases we want to provide high quality teaching.

While it is possible for the AAS to build a large-scale effort to help in this regard I would propose that a structure already exists that could be tapped into. The American Association of Physics Teachers has a space science and astronomy committee which provide sessions at meetings to help improve astronomy teaching. I would propose an effort to build a stronger bridge between these two societies, especially in the timing of national meetings, to merge the best that each society has to offer and build on the synergy of the two.

2) American Astronomical Society Associate Clubs/Organizations. Similar to the Society of Physics Students, but with potential membership from a wide variety of clubs and societies.

About a month or two before the call for white papers I had written on my whiteboard a short line that said SPS to AAS. In reality, I am proposing something slightly broader than just duplicating a student organization such as SPS. There are many astronomy clubs scattered throughout the country, some of which are associated with schools, while others are not. I can envision these organizations acting in a similar manner to the AAS agents program which was started a few years ago. These groups would be the eyes and ears of the society scattered throughout the country, and potentially in other countries. I don't know all the details of such an organization, but I can see the potential in helping with a number of items listed on the previous page.

Potential Associate Groups

1) University/college astronomical societies, or just departments
2) Public/private astronomy clubs
3) High school clubs
4) Other groups associated with astronomy in some way

One thing which bothers me at AAS meetings are student tags at meeting which say non-member. Although this is an accurate description it seems to set these people apart as not actually being part of the meeting. The creation of an associate member structure made of the kind of groups listed above could help alleviate this problem. It would leave the traditional members of the society, junior members are those currently along the track to become full members of the society, and a new associate member level for those whose careers or interests could take various paths not just astronomy. One great advantage I note here is the use of these organizations as the public outreach arm of the AAS and the society would just need to provide a central clearing house structure and not recreate something already being done.

While the current structure of membership at the AAS works well for those students who plan to continue on a professional track in astronomy and astrophysics, there are other students who would benefit from attending meetings but for which normal membership doesn't make sense. Personally I love the idea of those who will be teaching our K-12 students throughout the country having had a real research experience and being able to attend a professional meeting. Then when students ask them how we know something, they can share personal experiences of how science is done. This could have an enormous impact on the upcoming generation. Because of the experience of a few students planning on K-12 teaching as a career, a new generation of teaching students is seeking formal research experiences in astronomy. This is one place I really want to see the AAS provide greater support.

Potential benefits to both the AAS and associate groups:

1) Increase overall society membership.
2) Local associate members could be brought in as support for meetings near their location. It would also make members of those groups feel welcome to present at the national meetings. Also for public star parties when appropriate.
3) The associated member organizations could use the AAS name in advertising and at any event.
4) Increase the attendance at many of meetings, in particular summer meetings. Perhaps specialized sessions for amateur astronomers to present and get connected with professionals.
5) An organization to help share best public outreach practices and material, with the AAS serving as a clearly house. With events such as eclipses and transits it would be a central source of information.
6) Help those whose goal is not to be a professional astronomy, but are important to the overall astronomical community. Really thinking of teachers here and more especially teachers in training.
7) This is a way to bring some of the amateur astronomy community under the umbrella of the AAS.
8) Potential to have a large impact on STEM education by providing future teachers with outstanding experiences. Maybe stay associate members while being high school teachers.

At this point I do not have many of the answers to how such an organization would be built. This will be a place for those from the education committee, and others assigned by the society, to discuss how such a plan could be organized for maximum benefit to all involved. I believe that there should clearly be an annual membership for the organizations detailed here. Members of those organizations would then be eligible to apply for membership in the newly created associate member category. I like this option for the undergraduate students I bring to meetings since some are not sure of their career path. I could also envision this being used in connection with the undergraduate Chambliss awards, but that could be explored later.

3) Planetarium Utilization

In some ways I'm not 100% certain what my idea is at this point. I sometimes hear from our planetarium director that the planetarium organizations are often more focused on the financial side of planetarium shows then on the educational side. I'm not sure if it is the AAS's role to help focus on the educational side, however I would guess that many AAS members are associated with schools which operate a planetarium. I would recommend some thought be given new ways to help promote planetariums as educational tools more than just moneymakers.

White Paper on African American Astronomy Graduate Students (via email message)
Jarita Holbrook and Sharon Traweek

From Jarita:
The myth of white intellectual superiority is such that incoming graduate student believe that African American students have gotten in through Affirmative Action and therefore are not intellectually up to standards. These students are condescending and adopt a parental but nonetheless superior attitude towards the African American students. This results in an attitude of not wanting to include African American students in their homework and study groups since they believe they cannot contribute intellectually to the group. The African American students pick up on these negative attitudes and as a result do not want to work with those students either. This is a very negative feedback loop to the detriment of the African American students. This leads to the student isolating themselves and in general holding anger and frustration as the way they are treated by their peer.

A second trend is when the African American student defies expectations and passes the qualifying exam. The faculty unfortunately responds in several negative ways: 1) accusations of cheating, 2) putting extra conditions on the students even after they have passed (thus treating them as if they didn't pass), and 3) changing the exam to make it 'harder' so such a student cannot pass in the future. Again, this leads to the student isolating themselves and anger and frustration, etc, except it is towards the department and the field leading to them leaving upon graduation or soon after.

In my interviews with African American students, these have come up especially with lower class/poor students and those from HBCUs doing graduate work in White universities.

I'm not sure if cross cultural training would help with these, however if departments know that I am collecting data on this perhaps they will stop behaving so badly and educate their students to behave better, too.

From Sharon:
I believe we have not yet met face-to-face; I look forward to that.
Meanwhile, our team has much to report about the strategies grad students, postdocs, early/mid/senior career astronomers have used to learn what/how to learn what needs to known at each career stage. From our various shared/individual projects our team has about 200 oral histories with astronomers and about 100 with others in the physical sciences; we are studying the patterns. As Jarita shows so powerfully, minorities/women/migrants [MWM] find a repertoire of peer shared learning practices to be crucial for dealing strategically with all the

marginalization/bullying MWM encounter. Those strategies are great and their circulation is very important; meanwhile, the community must learn to stop the bullying, including that so very thinly disguised as merit discourse.

Dr. Eric Hooper (ehooper@astro.wisc.edu), UWMadison, Astronomy and Physics
Dr. Robert Mathieu (mathieu@astro.wisc.edu), Director of the Wisconsin Center for Education Research, UWMadison, Professor of Astronomy
Dr. Christine Pfund (christine.pfund@wisc.edu), UWMadison, Director of the Center for the Improvement of Mentored Experiences in Research
Dr. Janet Branchaw (branchaw@wisc.edu), UWMadison, Director of the Wisconsin Institute for Science Education and Community Engagement, Assistant Professor of Kinesiology
Dr. Kathryne Sparks Woodle (woodle@aps.org), American Physical Society, CIMER Wisconsin Center for Education Research, University of Wisconsin, Madison

CIMER Center for the Improvement of Mentored Experiences in Research

White Paper on Improving Mentored Experiences in Research in Astronomy and Physics
A response to the call by the education task force of the American Astronomical Society

Introduction.

The responsibility and opportunity to mentor the next generation of astronomers during research apprenticeships has been a key driver of progress in the field for generations. How did those of us who are now supervisors of undergraduate and graduate research students learn to mentor in the first place? Presumably we took what we liked from our own experiences as mentees, rejected what we did not like, and then "just did it." Many of us used to take a similar approach to teaching. However, now we have learned that there are a variety of best practices, techniques for focusing on the learners, evaluation procedures, etc. in the classroom. It is now time to take a similar and more systematic approach to mentoring research apprentices.

Our goal is for every astronomy department and astronomy research organization in the country to consider research mentoring as a skill to be developed and applied mindfully much like teaching in its best incarnations. Research supervisors would routinely consider items like expectations, communication, how to assess whether a mentee really understands material, how to motivate effectively, etc. Institutions would consider the role of research mentoring in attracting and retaining a more diverse population of new and developing astronomers.

The AAS is already committed to fostering a positive mentoring experience for its members. Indeed, item 4 in the five-element AAS mission and vision statement (https://aas.org/governance/aas-mission-and-vision-statement) declares that "the Society, through its members, trains, mentors and supports the next generation of astronomers." Sessions, mostly sponsored by the Committees on the Status of Minorities / Women in Astronomy (CSMA and CSWA), on mentoring awareness, research mentor training, mentoring and networking have occurred at some of the bi-annual society meetings. We call upon the AAS to build on this commitment and these efforts to promote effective research mentoring more widely and deeply across the discipline.

The unique position of a professional society transcends institutions.

Individual departments and research groups may not have the time or resources to adequately investigate and implement mentor training opportunities and materials. Like it has for classroom instruction, the AAS can provide encouragement, guidance, recommendations, and an overview of available resources to improve the mentor and mentee experience.

We have the opportunity to work together with our sister organization the American Physical Society (APS) to promulgate better awareness of mentoring responsibilities and opportunities, disseminate training and self education materials, and foster a more inclusive, responsive, and effective developmental experience for the next generation of scientists across both disciplines.

The APS also recognizes the importance of mentoring as a key component in the success of physicists, especially those from underrepresented backgrounds in physics. Through collaboration with UW-Madison and the Center for the Integration of Research, Teaching and Learning in 2011, the APS produced the *Physics Research Mentor Training Seminar*, a facilitation guide to train those in mentorship roles in physics research, building on the evidence-based practices from the *Entering Mentoring* curriculum created by Dr. Jo Handelsman, Dr. Christine Pfund, and colleagues. Staff at the APS participated in an extensive train-the-trainer workshop to build capacity within the organization to offer mentor and mentee training sessions at scientific meetings and educational conferences, including the annual conference of the APS National Mentoring Community (NMC). The NMC was created in 2015 to support undergraduate students from underrepresented racial/ethnic minorities in physics in their pursuit of bachelor's degrees in physics. Pairing local faculty and students, the NMC aids the development of mentoring relationships by providing resources throughout the year as well as during the annual conference. Participants gather to share experiences, discuss best practices, and build stronger connections within the physics community. The APS has made a substantial commitment of resources to establishing this mentoring community through staff time, student travel funding, and oversight by the APS Committee on Minorities. Future actions of the NMC involve establishing national mentoring awards and scholarships for students.

Focus on the apprentice relationship, not just the classroom.

Though improving teaching and learning in the classroom is important for increasing and broadening access to careers in astronomy, providing engaging research experiences for future astronomers is equally foundational. The pathway we have followed to improve teaching and learning in the classroom can serve as a model for efforts to improve mentored research experiences. Advances in teaching and learning have resulted from the use of evidence-based practices. Likewise, there are evidence-based practices for developing and nurturing effective mentor - trainee relationships, such as aligning expectations, communicating effectively and frequently, and creating opportunity for increased trainee independence over time. Like the implementation of effective teaching and learning practices, approaches to nurture an effective and rewarding mentor - trainee relationship should be customized for individual mentors and trainees, depending on their styles and needs. Process-based curricula, such as *Entering Mentoring* and *Entering Research*, are grounded in evidence-based practices, yet are flexible enough to be customized. The AAS can buttress research trainee programs across institutions and at all levels, from undergraduate to post-doc, by supporting the incorporation of these, or other similar curricula, into our astronomy research training programs across the country.

Increase the diversity of the astronomy workforce.

Research from across disciplines indicates that mentoring has a positive impact on career success, satisfaction, and commitment. For undergraduates, mentored research experiences have been linked to gains in research skills and productivity as well as retention in science. The frequency and quality of mentee-mentor interactions has been associated with students' persistence in STEM degrees. Graduate students who are mentored effectively are more likely to persevere in academic pursuits; positive mentoring is cited as a critical factor. For students from underrepresented racial and ethnic groups, mentorship has been shown to enhance recruitment into graduate school and research-related career pathways. The AAS recognizes some of the important mentoring roles for diversifying the field in its strategic plan (https://aas.org/about/strategic_plan), but the plan omits mention of perhaps the most critical aspect of mentoring, that of the mentor and trainee in the conduct of research. Because of the vital role mentoring plays in trainee persistence, especially among traditionally underrepresented groups, it offers a target for interventions aimed at diversifying the astronomy workforce.

Action items for the AAS.

- Provide leadership within the discipline for research mentor and mentee training.
- Provide frequent in-house training sessions, such as research mentor/mentee workshops, at Society meetings.
- Reinforce the integration of research mentoring considerations into diversity efforts.
- Foster a research mentoring network.
- Build capacity within the profession, for example by training trainers. This could be done at both national and regional levels.
- Provide links to research mentoring resources.
- Establish a Society award for research mentoring.
- Partner with the American Physical Society to improve the mentor and mentee experiences for researchers in both disciplines.

Thank you for your consideration.

With best regards,

Dr. Eric Hooper (ehooper@astro.wisc.edu), UW-Madison Astronomy and Physics

Dr. Robert Mathieu (mathieu@astro.wisc.edu), Director of the Wisconsin Center for Education Research, UW- Madison Professor of Astronomy

Dr. Christine Pfund (christine.pfund@wisc.edu), UW-Madison, Director of the Center for the Improvement of Mentored Experiences in Research

Dr. Janet Branchaw (branchaw@wisc.edu), UW-Madison, Director of the Wisconsin Institute for Science Education and Community Engagement, Assistant Professor of Kinesiology

Dr. Kathryne Sparks Woodle (woodle@aps.org), American Physical Society

Addendum

Statement of support from the Center for the Improvement of Mentored Experiences in Research

The Center for the Improvement of Mentored Experiences in Research (CIMER) at UW-Madison supports the submission of this white paper to the American Astronomical Society.

CIMER works to improve the research mentoring relationships for mentees and mentors at all career stages through the development, implementation, and study of evidence-based and culturally-responsive interventions.

CIMER Advisory Committee Members:

Dr. Christine Pfund, Director of the Center for the Improvement of Mentored Experiences in Research

Dr. Chris Brace, Radiology and Biomedical Engineering

Dr. Janet Branchaw, Kinesiology, Wisconsin Institute for Science Education and Community Engagement

Dr. Angela Byars-Winston, School of Medicine, Center for Women's Health Research

Dr. Andrew Greenberg, Chemical and Biological Engineering, Institute for Chemical Education

Dr. Eric Hooper, Astronomy and Physics

Dr. Robert Mathieu, Astronomy, Wisconsin Center for Education Research

Dr. Stephanie Robert, Social Work

Dr. Chris Sorkness, Pharmacy, Institute for Clinical and Translational Research

Dr. Amber Smith, Faculty Associate for Research Mentor/Mentee Programs, Wisconsin Institute for Science Education and Community Engagement

White Paper for Education/Professional Development

My background – Sethanne Howard, PhD

Former Shapley Lecturer
Former University Lecturer in astronomy
National Lecturer on the history of women in science
Former Chief of the Nautical Almanac Office, USNO
Current *Project Astro* astronomer with the *Benjamin Banneker Historical Park and Museum*
Volunteer at the *Robinson Nature Center*, Howard County, Maryland

After having taught university level astronomy I quickly learned that most colleges and universities that teach astronomy for non-majors do not have professional astronomers teaching the classes. This was strongly reinforced when reading the Facebook page on Astronomy Education. The questions and comments clearly indicate that most teachers of astronomy are not professional level astronomers.

These classes are often the only science many people see in their college career. They are cheated of the beauty and fascination of astronomy when a lecturer with no background in astronomy teaches their class. Even worse than that, we turn out graduates who lack the clarity of thought that comes from the study of astronomy. It is incumbent upon the AAS as the professional representative for US astronomy to provide a set of standards for knowledge and concepts required of astronomy teachers. Our science is not buried under the auspices of other sciences. It is an independent science with a history that stretches back to the earliest human writings. Henry Norris Russell said it better I can.

According to Henry Norris Russell
"Astronomy is the oldest of the natural sciences: nearly the earliest records that we find in the annals of China and upon the inscribed "library bricks" of Assyria and Babylon relate to astronomical subjects, such as eclipses and the positions of the planets. Obviously in the infancy of the race the rising and setting of the sun, the progress of the seasons, and the phases of the moon must have compelled the attention of even the most unobservant.

As Astronomy is the oldest of the sciences, so also it is one of the most perfect, and in certain aspects the noblest, as being the most "unselfish," of them all.

Although not bearing so directly upon the material interests of life as the more modern sciences of Physics and Chemistry, it is really of high utility. It is by means of Astronomy that the latitudes and longitudes of places upon the Earth's surface are determined, and by such determinations alone is it possible to conduct vessels upon the sea. If we can imagine that some morning humans should awake with Astronomy forgotten, all almanacs and astronomical tables destroyed, and sextants and chronometers demolished, commerce would practically cease, and so far as intercourse by navigation is concerned, the world would be set back to the days before Columbus. Moreover, all the operations of surveying upon a large scale, such as the determination of the boundaries of countries, depend more or less upon astronomical observations. The same is true of all operations which, like the railway service, require an accurate knowledge and observance of the time; for the fundamental time-keeper is the diurnal revolution of the heavens, as determined by the astronomer's transit-instrument. …

Apart from the utility of Astronomy in the ordinary sense of the word, the study of the science is of the highest value as an intellectual training. No other science so operates to give us on the one hand just views of our real insignificance in the universe of space, matter, and time, or to teach us on the other hand the dignity of the human intellect as the offspring, and measurably the counterpart, of the Divine; able in a sense to "comprehend" the universe, and know its plan and meaning. The study of the science cultivates nearly every faculty of the mind; the memory, the reasoning power, and the imagination all receive from it special exercise and development. By the precise and mathematical character of many of its discussions it enforces exactness of thought and expression, and corrects that vague indefiniteness which is apt to be the result of pure literary training. On the other hand, by the beauty and grandeur of the subjects it presents, it stimulates the imagination and gratifies the poetic sense. In every way it well deserves the place which has long been assigned to it in education."

So I beseech the AAS leadership to consider establishing a set of standards for teaching introductory astronomy; not a list of facts to know, but a set of concepts to understand and explain. I volunteer to serve on such a committee.

Increasing Diversity in Astronomy and Physics
Deidre Hunter, Lowell Observatory
May 9, 2016

For the past 20 years I have run a program that uses astronomy hands-on activities to help teachers get 5^{th}-8^{th} grade Navajo and Hopi students excited about science. This was based on the assumption that, if students had fun doing science, the rest – continuing to study science and maybe going on to a career in it – would follow naturally. But now I no longer believe that that is sufficient for minority students.

The March 2016 issue of *Physics Today* contains an open letter by Dr. Paul Camp to Supreme Court Justice Roberts. The occasion for the letter was Robert's question during oral arguments, "What unique perspective does a minority student bring to a physics class?" Dr. Camp lays out the evidence that those outside the mainstream bring a different perspective and hence are more likely to also produce the major paradigm shifts. However, Dr. Camp brings up another point about bringing minorities into physics. As someone who spent a decade teaching physics at a historically black women's college, he found that he needed to go beyond teaching physics to his students; rather, he needed "to help students to see a physicist in themselves." With hindsight, this makes sense. The majority of Navajo and Hopi middle school students, when asked to draw a picture of a scientist at the beginning of the school year, inevitably describe a white man in a lab coat with a foreign accent. How can this apply to them? And when asked what career they see for themselves, they list the jobs they see around them, such as gas station clerk or policeman or teacher.

But what does it mean to help them see themselves as physicists when direct role models are lacking? A new (to me) form of education is called Project Based Learning. This is described as allowing "students to learn by doing and applying ideas. Students engage in real world activities that are similar to the activities that adult professionals engage in." This type of education, which is used in the kids' summer camps at Lowell Observatory, is perhaps what minority students need to help them see themselves as scientists. I recently saw a documentary "Navajo Math Circles" about an informal education program on the Navajo Nation. It takes the form of a summer camp or after school program that brings students together with mathematicians, and leads the students from solvable problems to open-ended problems. I believe it has been successful in producing students who want to go on in STEM fields just because it helps students see themselves as mathematicians. The critical question for the Education Task Force is how do we bring this type of education to every student in the country?

Making the AAS More Relevant, and Known of, to Younger Astronomers
AAS Task Force White Paper

--Leah Jenks

One of the biggest things I can suggest about making the AAS in general as well its education and outreach branches more accessible and relevant to the younger generation is simply making its presence known. In my thoughts about this issue as well as discussions with another professor about getting young astronomers interested in an AAS women in astronomy interview series, the main issue that came up is that most undergraduates don't realize that the AAS is or should be an important resources for them. For many, (including myself until recently) the AAS just seems like an abstract entity that has no real bearing on our undergraduate careers in astronomy or astrophysics. For example, I was not aware that undergraduates were able to join the AAS as junior members until very recently.

I think that the most effective way to approach this problem and to get more young people involved is through individual departments. Presumably any department that offers an astronomy major will have several faculty who are members of the AAS, and through these faculty, students should be able to learn about ways they can get involved with the AAS and the greater astronomical community. I think that most faculty members would be more than willing to help a student who wants to be more involved, however I think that most of the time, students don't even know to ask. If a department has some sort of welcome seminar or event early in the fall semester, as Colgate does; an effective way to implement this would be to have some sort of brief announcement during that, to introduce students to the AAS as an organization. That way interested students could know where to go if they wanted to learn more. This would also be a good way to get more students involved in the social media aspect; many people would be interested and want to follow a relevant twitter account for example, but may not know that it exists.

In terms of what undergraduates and younger members of the astronomical community may want from the AAS, I think that the two biggest things are networking and making connections with professionals in the field, as well as being aware of news and current events in the community. Currently, there definitely seems to be a disconnect between undergraduate students and graduate students and the rest of the professional astronomical community, and the best thing to do to involve more people would be to bridge that gap. Additionally, many students would be interested in the AAS's education and outreach efforts, as contributors as well as participants. I think that the main issue comes back to the fact that young people simply aren't aware of what the AAS does, how it is relevant to them or why they should care. I realize that this is a hard problem to solve, but I think that the best strategy is to start on the small, personal level with individual departments and professors, which will help to kick start a larger network of involvement.

How Smooth is the Transition from Academia to Industry?

Julia Kamenetzky, *NSF Astronomy & Astrophysics Postdoctoral Fellow, Steward Observatory* and Ian Crossfield, *Sagan Fellow, Lunar & Planetary Laboratory, University of Arizona*

The number of PhDs produced will always be greater than the number of tenure-track faculty jobs available at PhD-granting institutions.[1] As a result, many PhD recipients seek astronomy employment at other types of institutions (non-PhD granting institutions, national labs, observatories, public education/outreach centers) or non-astronomy-related employment, especially in data-driven industries such as technology and finance. The AAS Education Task Force may wish to address the issue of making sure graduate education adequately prepares students for such jobs, in addition to preparation for continued astronomical work. Some in the community have called for PhD programs to alter their curriculum focus to specifically train students for these industry jobs.[2]

Before advocating such changes, we recommend the AAS Education Task Force first answer these questions: do PhD students need additional training in order to transition to industry? If so, what specifically is that training? Finally, are faculty at PhD-granting institutions the appropriate people to provide this training?

The unemployment rate for PhD physicists and astronomers after graduation is $\leq$5%.[3] Roughly half of astronomy PhDs find jobs outside universities; of those who never took a postdoctoral position, one in six work in for-profit endeavors.[4] Thus, current graduate student training and education seem to enable PhD astronomers to secure employment outside academia. These statistics suggest that astronomers are already well qualified for industry positions. From our anecdotal evidence, our peers that have transferred to industry (with or without completing the PhD) are happy with their jobs and are well paid (with the exception of our peers in public education, unfortunately). Perhaps, at most, what is really needed is expanded education on the career paths outside of academia and how to navigate the non-academic job market, rather than additional skills-based training. Demonstrating that astronomers are qualified for other jobs will also ease the anxiety many young astronomers have about their career prospects. Furthermore, most faculty at PhD institutions have always been in academia, and may not be well-versed on the fast-paced and changing environments of various industries.

For a long time, PhD astronomers have had to seek employment other than tenure-track faculty at PhD granting institutions. Certainly, senior astronomers and especially professors should avoid any devaluing of students' career choices given the realities of the job market. But before significantly modifying or changing the goals of graduate curriculum, we recommend the AAS Education Task Force study whether graduate students are truly prevented from obtaining those jobs. In essence, we suggest a difference in the framing of the problem: astronomers are not deficient in the skills desired by industry, and graduate education should empower students to use their marketable skills in their desired career path.

[1] H.A.J. Thronson, PASP **103**, 90 (1991).
[2] B.A. Cooray, A. Abate, B. Häußler, J.R. Trump, and C. Williams, arXiv:1512.02223 (2012).
[3] J. Pold & P. Mulvey, https://www.aip.org/statistics/reports/physics-doctorates-one-year-after-degree (2016)
[4] R. Ivie, https://www.aip.org/statistics/reports/results-longitudinal-study-astronomy-graduate-students (2015)

Availability of AAS Job Register Statistics

Julia Kamenetzky, *NSF Astronomy & Astrophysics Postdoctoral Fellow, Steward Observatory, University of Arizona*

Educators and mentors of students interested in pursuing astronomy as a career should be able to accurately describe the state of the job market. To make it easier for the community to update and analyze job-related statistics, I've compiled a public github repository of such data at https://github.com/jrka/astrojobs.

This repository includes data on every job posting on the AAS Job Register from 2002 until the present. Each job posting includes its posted date, job title, job category, institution, and institution classification. The repository also includes scripts used to generate this table, from which a user can also save the full text of the job description. I have also included a script that makes some summary plots and text, but users could choose to examine the data table in their own way.

Previous studies of the job market for astronomers such as Metcalfe 2008 (http://iopscience.iop.org/article/10.1086/528878) have been very useful in illustrating trends in the job market over the past few decades. My goal is to allow astronomers to easily replicate these studies and update the statistics as time goes on. To that end I've also included tables of astronomy funding by year, numbers of PhD recipients over time, and some pre-2002 Job Register data from Metcalfe 2008.

I'll also be sharing this with the AAS Employment Committee, but wanted the AAS Education Task Force to also know about its availability as they discuss the state of professional development and education at the undergraduate and graduate levels.

Lessons from a Structured Program for Undergraduate Research

Chuck Keeton
Professor, Department of Physics & Astronomy
Faculty Director, Aresty Research Center for Undergraduates
Brian Ballentine
Executive Director, Aresty Research Center for Undergraduates
Rutgers, the State University of New Jersey

Participating in authentic research contributes to students' academic, personal, and professional growth (DeHaan 2005; Lopatto 2007; American Association for the Advancement of Science, 2011). The benefits of undergraduate research are clearly recognized by the astronomical community, as evidenced by the growing number of summer research programs and student presentations at AAS meetings. Yet, despite their tremendous value, summer research programs are limited in two ways. First, residential programs are expensive and so capacity remains well below student demand. Second, many summer programs cater to students from outside the host institution. Few departments in any discipline offer clear and structured paths for their own undergraduates to participate in research during the academic year.

Based on our experience with undergraduate research at Rutgers University, we suggest that a well-designed program for academic-year research can increase capacity and provide access to a broad range of students at a relatively low cost. Below we summarize the array of programs offered by the Aresty Research Center for Undergraduates; here we focus on the Research Assistant Program that provides an entry to research during the academic year. Two features of the RA Program have made it successful for students and faculty alike:

1. *A transparent, structured application process.* Each year, professors submit brief descriptions of their current research projects to the Aresty Center, along with specific tasks for undergraduate researchers, mentoring plans, and lists of applicant requirements. Students can then search the Aresty database and apply directly to specific projects by uploading a personal statement and CV through the Aresty website. Having fixed deadlines helps faculty manage the recruitment process, while having a centralized application system helps students identify research opportunities and helps professors find students who are the best fit from a broad applicant pool.

2. *Ongoing professional development for students through peer education.* Many students struggle to navigate the expectations of professors, the pace of research, and competing academic priorities. The quality and intensity of mentorship students receive from professors varies. To address these challenges, the Aresty Center has created a curriculum of peer discussion groups focused on managing research relationships and sharing research with diverse audiences. The groups are led by students who are themselves experienced scholars and leaders and are therefore familiar with the challenges new researchers face.

A structured application process and professional development activities are familiar components of summer research programs, but they have not fully diffused into academic-year research programs for students in their own departments. We believe that adopting them, together with peer education, would provide more transparent pathways into research for more students. Creating such pathways may have specific benefits for students from underrepresented groups, who may not have the networks, support, or coaching to pursue research opportunities through the traditional model of knocking on doors (Hurtado et al. 2011). By making opportunities for mentorship transparent and open to any applicant, the field will draw upon a more diverse pool of aspiring researchers.

Aresty Research Center for Undergraduates

The Aresty Research Center for Undergraduates was founded in 2004 by a gift from Jerome and Lorraine Aresty and continues to receive support from the Division of Undergraduate Academic Affairs. The core programs (and approximate number of students served per year) are as follows:

- First-year research seminars (200)
- Summer Science Program for rising sophomores who are new to research (60)
- Academic-year Research Assistant Program for students in all disciplines and class years who are new to research (350)
- Undergraduate Research Fellowships for advanced student researchers (200)
- Travel support for students who are accepted to present their research at conferences (50)
- Undergraduate Research Symposium (500)

Here are some recent accomplishments at the Aresty Center:

- Curricular enhancement: We have refined the curriculum for peer group meetings to highlight professional and social aspects of research, including effective communication as well as ethical responsibilities in research. We just completed a transition that allows us to award academic credit to students who participate in the academic-year Research Assistant program.
- Proposal review: We have modeled the Undergraduate Research Fellowships program on the professional funding process. Students submit research proposals that explain the merit and impact of the proposed work and include detailed budgets, and we convene a faculty review board to evaluate proposals and provide feedback to students as part of the learning process.
- Research seminars: We have partnered with the Byrne Seminar Program at Rutgers to create special courses that introduce small groups of first-year students to authentic research activities in a classroom setting. The seminars address cutting-edge questions in science, engineering, social science, and the humanities, and they use hands-on activities in the lab, field, or archive to help students gain confidence in the practice of research.

- Corporate engagement: We have started to welcome executives from area businesses as guest judges for the Undergraduate Research Symposium and guest speakers for peer group meetings.

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Platform to Share Our Ideas and Classroom Materials

Education White Paper (received in body of email)

Jonathan Keohane <jkeohane@hsc.edu>

From my point of view, as a professor at a small liberal arts college, the most important thing for the AAS to do is to provide some platform for us to share our ideas and classroom materials in a way that real people would actually use. This is a solvable problem, and I am sure the task force could address it.

The trick is that it has to be both closed (only AAS members) and open (every AAS member has equal voice). This is not the PER model of getting a grant, and doing some sort of social-science type measuring, but rather a social media, get-hub, blog, wikipedia, and/or astro-ph type model.

We astronomers are already at the leading edge of archival data resources and such like that, but somehow our EPO initiatives seem to be either about the public outreach side (How do we promote our great new telescope so we get more government money for it?), or on the side of developing curricula that may later be published in a book or something.

The problem with the public outreach model, is that it does not teach any real skills. But, we teachers of astronomy routinely find stuff, and use it in our classes to teach our classes in one way or another.

The problem with the committee producing something model is that every time this has been done in the past, it has been for the benefit of the people producing the materials, rather than as a public good for the Astronomical community as a whole. In other words, it produces something that a student would buy, say a workbook (like lecture tutorials), rather than something that we can easily find, download, and then edit in any way we see fit four our own class.

The best example of this was Project Star, where a committee at the CfA carefully developed a wonderful curriculum for high school astronomy with the goal of teaching broad scientific skills. But, what happened to it over time? I still copy pages from that old book to include in my Astronomy 101 classes, but more often than not I just develop my own materials.

When I teach Astronomy 101, I use the old paperback by Timothy Ferris “Coming of Age in the Milky Way.” as the framework for the course, and then I develop my own materials. This way I can take a first principles, historical, and mathematical approach. Like the Project Star approach, I use astronomy as an excuse to teach the process of science and important numeracy skills.

Perhaps I will write an Astro textbook based on these ideas, so I do not want to just "give everything away." On the other hand, I would love to share them around, especially if I get helpful feedback. Similarly, I have developed many astronomy labs, which I am always happy to share, but they usually need to be tailored to a particular set of students learning the material in a particular way.

I may consider trying something new, and someone else may already have experience with it. For example, has anyone written Jupyter (formerly iPython) notebooks for teaching astronomy?

So, in short, I would like the task force to concentrate on actually developing a platform, with the same thought and professionalism that is used for research data archives, but tailored to allowing for a free-flow of helpful, and tailorable, ways to share materials and information among colleagues, that is both easy to use and secure from current students doing a quick google search while doing their homework.

MARKETING for SCIENTISTS

Whitepaper by Marc Kuchner
NASA Goddard Space Flight Center
Marc.Kuchner@nasa.gov

When the economy crashed in 2008 and the postdocs and students at Goddard Space Flight Center came to me for help finding jobs, I found myself short on meaningful advice to give. I imagined that one way forward could be for scientists to learn techniques from business and marketing, like branding, salesmanship, and social media. So, with help from the scientific community, I wrote a book and developed a series of professional development workshops to help scientists learn these tools and apply them to win jobs and grants, improve the culture of science, and help shape the public debate. The book is called *Marketing for Scientists: How to Shine in Tough Times* (Island Press, 2011).

Since then, I've had the privilege of teaching marketing techniques to scientists of all kinds: cancer researchers, engineers, entomologists, geologists, molecular biologists, oceanographers, physicists—and many astronomers. A partial list of my clients is below. Marketing comes into play in nearly every aspect of a scientist's career, so my workshops touch on networking, presentation skills, grant writing, conferences, what to put on your website, even how to decorate your office. Postdocs and graduate students find my workshops crucial preparation for entering the job market, and senior scientists find them a source of new tricks for communicating their work to funding agencies and the public. A legal agreement I signed with NASA specifies that my workshop will be free to all U.S. astronomers. **I am writing to make you and AAS members aware of this free resource.**

Here are descriptions of some of my professional development workshops. For more information, go to www.marketingforscientists.com/workshops.

Modern Marketing for Scientists (90 minutes): Many scientists know they need to market their work–but what does that really mean? In this workshop, we'll talk about marketing, sales, and branding: what those words mean in the business world and what they mean to us scientists. We'll invent brand names and logos and talk about how to start a conversation about your work. How can you "sell" something without losing your credibility? What's even better than an elevator speech? Come to this workshop to find out.

Talks, Figures, Proposals (90 minutes): The old cliche is that your science talk or your proposal should "tell a story". But what does that really mean? We'll talk about tell a story using text and figures, and some concepts from the new field of neuromarketing. Come to this workshop to learn about three kinds of figures every scientist needs, four kinds of proposals not to write, and the Star Wars formula for how to structure a colloquium talk.

Internet Marketing for Scientists (90 minutes): Before you enter today's competitive job market or apply for your next grant, you'll want to kick your internet presence in high gear. But where to start? The black hole of blogging? The time suck of social media? This workshop will help you harness the web to share your science with your colleagues, your funding organizations and the public, while avoiding some of the web's many pitfalls. We'll talk about Facebook, YouTube, Wikipedia, Blogging, Email Marketing, Citizen Science, and basic marketing strategies that will help you in all aspects of your career. Bring your laptop: we'll get some of the work done it real time so you can get right back to unlocking the secrets of the universe–with more love from your colleagues online.

Marketing for Scientists Partial Client List

Argonne National Laboratory
Boston University
Caltech
City of Hope Cancer Center
Columbia University
Drexel University
European Southern Observatory (ESO) Headquarters
Florida Institute of Technology
Harvard Medical School
Harvard-Smithsonian Center for Astrophysics
Infrared Processing and Analysis Center (IPAC)
Los Alamos National Laboratory
Maria Mitchell Observatory
Massachusetts General Hospital
Max Planck Institute of Molecular Cell Biology and Genetics
Moffitt Cancer Center
NASA Headquarters
NASA Langley Research Center
NIH National Human Genome Research Institute (NHGRI)
National Postdoctoral Association
NSF Astronomy and Astrophysics Postdoctoral Fellows Symposium
Penn State University
Salk Institute for Biological Studies
Santa Fe Institute
Stony Brook University
The Nature Conservancy
The Scripps Research Institute (TSRI)
Tufts University
University of Arizona
University of California, San Diego
University of Florida, Gainesville
University of Hawaii
University of Maryland, Baltimore County
University of Maryland School of Medicine
UMASS Amherst
University of Toledo
Yale University

White Paper about SETI Courses for Students (received via email message)

Larry Lesyna lesyna@lxltech.com

The Search for Extraterrestrial Intelligence (SETI) has been deprived of federal funding for over two decades. Yet the recent detection of extrasolar planets in habitable zones around "good" stars bolsters the prospects for a successful search for ETI within 300 pc from our Sun.

About two years ago, I prepared a draft syllabus for an advanced course dealing specifically with SETI (attached). It was reviewed favorably by astronomers who have done SETI research and a few even expressed interest in offering a similar course to their students in the near future. Independently of my efforts, Prof. Jean-Luc Margot of UCLA is currently teaching an advanced SETI course with similar content.

I believe that a SETI course is both timely and beneficial to future astronomers. In addition, it also benefits the majority of science and engineering students, who like me, choose to pursue professional careers outside of astronomy. I would like to see a SETI course receive broader consideration within the astronomical community.

I welcome your thoughts and thank you for considering my suggestion.

Dark Skies, Bright Kids! and the Value of Repeated Interactions with Elementary School Students

Sandra E. Liss†, Kimberly R. Sokal†, Rachael L. Beaton‡, Kelsey E. Johnson†, and the DSBK Team
†University of Virginia ‡ The Observatories of the Carnegie Institution for Science

Dark Skies, Bright Kids! (DSBK) is a volunteer-run outreach program that targets underserved elementary school students in central Virginia[1]. The core mission of DSBK is to build positive attitudes about science through long term, one-on-one interactions with scientists in a non-traditional educational setting. The heart of the program is an eight- to ten- week after school "astronomy club" that covers a set of major astronomical topics. We present content to the students through a combination of demos and hands-on activities that build curiosity and excitement as they demonstrate those scientific concepts. This program is operated entirely by volunteers drawn from the students, staff, and faculty affiliated with the Department of Astronomy at the University of Virginia. Since our founding in 2009, these DSBK volunteers have contributed over 15,000 volunteer contact hours toward the education of students in central Virginia. DSBK is funded from education components of research grants, gifts from the community, outreach support funds at the University, and external grants. In recognition of its accomplishments, DSBK was honored as a 2012 "Program that Works" by the Virginia Mathematics and Science Coalition, the highest award for informal education programs in Virginia. In 2015, DSBK was awarded a grant from the David and Lucile Packard Foundation to facilitate a series of summer astronomy camps at rural locations in Virginia.

There are several unique aspects to the program that we believe are paramount to its success:

- **Our outreach model is built around developing meaningful relationships between students and scientists through repeated and prolonged interactions.** It has been noted that "random acts of EPO" have little lasting impact on the public[2]. AAS programs like the Astronomy Ambassadors promote the development of "ongoing, sustainable partnerships with schools or other organizations"[2], which is precisely what DSBK does. In our experience, while one time events (such as public observing nights) may expose students to science in an exciting way, repeated interactions are what lead them to be come invested in it. By taking a mentorship approach in our astronomy clubs, DSBK volunteers are able to build relationships with students on an interpersonal level to demonstrate that we (scientists) are not so different from them (students).

- **Our primary goal is to improve students' attitudes toward science.** While we do strive to teach our students basic astronomy concepts, our main focus is to encourage them to develop a positive connection to the scientific community. Many elementary school students have already become disillusioned with the scientific endeavor, not having been shown any clear connection

[1]For more information, go to our website at http://faculty.virginia.edu/DSBK/ or find us on Facebook at https://www.facebook.com/DarkSkiesBrightKids.

[2]https://aas.org/outreach/aas-astronomy-ambassadors-program

between science and their everyday lives[3]. We seek to break down any negative stereotypes they may hold by interacting with them as 'real live scientists.' Each DSBK activity is designed for the students to engage with science in much the same way we do as scientists, and care is given to emphasize that the students' own curiosity and enjoyment are important aspects of the scientific process.

- **DSBK itself is organized like a research group and depends on ideas from each volunteer.** Our volunteers collaborate to contribute to the overall mission of DSBK in much the same way that diverse scientists pool their individual expertise to solve a scientific problem. Furthermore, we grow and evolve according to the interests and input of the volunteers, which has resulted in our longevity (we are in our 8th consecutive year and 14th astronomy club). Though the vast majority of our volunteers have no formal instructional training, this model has allowed us to develop and implement novel outreach activities. As a result, our members themselves gain valuable experience in curriculum development, teaching, grant writing, and leadership, which has led to great success in other EPO endeavors; we have had five volunteers selected as AAS Astronomy Ambassadors; two who received NSF Postdoctoral Fellowships; one who held a postdoctoral fellowship at Southern Illinois University Edwardsville STEM Center for Research, Education, and Outreach; one alum who manages the Astronomy Education Program at the Smithsonian National Air and Space Museum; and another former DSBK volunteer who is now the Assistant Director for Education and Physical Sciences at White House Office of Science and Technology Policy.

- **We have built an assessment program into our outreach efforts.** We recognize the importance of being able to quantitatively demonstrate the effectiveness of our program[4]. This is complicated by the fact that many standard classroom evaluation metrics do not work within our non-traditional framework. We work to develop specific content goals along with each week's activities. We then create journal pages that are aligned with these learning goals, and analyze them each week to track how effective our activities are at conveying astronomy content. We also administer the Draw-A-Scientist test[5] to each student twice (once before the first day of their astronomy club and once on the last day) in order measure changes in student perceptions of scientists. These worksheets, in combination with volunteer observations and photo-documentation, allow us to pinpoint what is working and what needs to be improved. This crucial aspect of our program is still under development, and we hope that the larger astronomical and educational communities can assist us in improving it.

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We believe DSBK fills a highly desirable niche for informal science education. The program was founded to bring science to students who have limited access to science content from other informal outreach providers in our central Virginia community. We have been extremely successful in accomplishing our goals, demonstrated not only through our assessments efforts but also through feedback from students, parents, and teachers. For example, this quote from one of our students shows the positive influence our astronomy club can have in shifting their attitudes regarding science:

"I was gonna think it was boring but it was actually really fun! I was surprised."

Furthermore, we have found that our model of using scientist educators in a research group style organization that provides one-on-one interactions benefits not only our students, but also our volunteers. Volunteers gain valuable teaching experience, leadership skills, communication skills, grant writing experience, and networks within the community. The core components of DSBK can be easily translated to other institutions and communities and adapted to meet their specific outreach goals. We believe that the DSBK framework could be useful as a model for developing similar programs and, as an organization, are interested in supporting future efforts to do so[6] .

[6]Kimberly Sokal & Sandra Liss *Making Science Fun: The "Dark Skies, Bright Kids" Program*. Mercury Magazine, 43, 3, 2014.

Achieving More Inclusive Science Education

Nicole Lloyd-Ronning and Christopher L. Fryer
Center for Theoretical Astrophysics, Los Alamos National Lab

Science progresses optimally when people from a wide range of backgrounds participate, and a variety of perspectives are included. It is crucial, therefore, that there exists the opportunity for any person with a desire and willingness to pursue a career in a STEM field to do so. In any type of science education, it is necessary to give young students - particularly those who falsely discount themselves as future scientists - the message that science is a field open to everyone. Many students misunderstand what it takes to be a scientist, and not only potentially miss out on a career that might be right for them, but on making a lasting contribution to science and humanity.

In the last five or ten years, an enormous emphasis has been placed on using technology to enhance science education Although there are undoubtedly many excellent online tools and technology based resources to improve STEM education, it is important to not forget the essential requirement of human interaction (particularly between students and professional scientists) in engaging future scientists. There are a few ways this can be done, with the potential for lasting positive impact.

Hands-on Activities

Most scientists who do public outreach with school age children would agree that to keep kids engaged in the short term, hands-on activities are far more effective than lectures. In particular, an approach in which small teams of kids are given a problem, and then given materials to explore the question (without directions or instruction on how to do so) can be extremely effective in engaging the students. As a simple example, in a second grade class, teams of two students are given an aluminum can and a balloon and asked to move the aluminum can across the room without touching it or blowing on it (they eventually discover a static electric force from the balloon will do it). The exploration is extended as the kids are given additional materials and challenges that reinforce the concept (for example, a filled water bottle with a hole in the lid, a plastic rod and piece of wool; they are asked to “bend” the water stream). The activities not only drive home a particular physical concept, but the kids are given room to explore their own ideas and tend to be genuinely engaged and excited about the topic when this approach is taken.

The challenge of this approach is that special care must be taken to draw out quieter, shyer students, making sure they have a voice. The scientist must also ensure that all students are given the opportunity to ask or answer questions. This approach can be a positive start in the goal of more inclusive science education, but for the long term, more must be done.

Engaging Students in Scientific Research

As kids get older, they are able to grasp and handle more difficult physical concepts. One positive way to engage kids more deeply in science is by offering a program in which kids work in teams on open-ended research problems. There are a few key points in making this an inclusive experience: 1) The class should be open to everyone, regardless of math or science background. 2) The topics are student directed and have many components (theory, observation, data analysis, computation) to allow students to explore the component of science that interests him/her the most. 3) Students work in small teams to promote collaborative effort. 4) The teams are mentored by scientists also engaged in the research problems.

A research problem that might be appropriate for this type of program is, for example, examining rotation curves of galaxies to determine the dark matter distribution (or potential modified theories of gravity). There is a data component (extracting the rotation curve from observations), a theory component (constructing dark matter distributions and/or modified theories of gravity), and a computational component (fitting the models to the data, modelling detailed mass-to-light ratio profiles, etc.) - any of which the student can tackle, depending on his/her interests. Examining pulsar kicks and spins is another multi-component research topic that could be accessible to students.

There are many advantages to this approach . First, students see how science is really done - that it consists of open-ended, multi-component problems, and is rarely done alone. Because these are real research problems, there is also potential for the work to be published, and for students to make a real contribution to science - this can be extremely motivating for high school or young undergraduate students. Most importantly, because it is open to all students and not just an elite academic group, the hope is that those students who might not think of themselves as scientists discover that in fact they are, potentially increasing the future diversity of STEM fields.

Mentorship

Finally, one-on-one mentorship is an extremely important way to engage and keep a student interested in science. Programs supporting this type of mentorship (through online resources pairing scientists with interested students) can have a lasting effect. When this is not possible, programs that support scientists pairing with teachers can be very effective as well. Because the students see their teacher every day, a positive relationship between scientists and teachers could have an important impact on how the students view science.

Support for these types of programs from AAS could include mini-grants (up to ~ $500 to $1000) for materials to use in the classroom, online documentation of successful outreach programs, and online resources pairing scientists with students and/or teachers.

These types of personalized interactions between students and scientists can go a long way toward opening science to a more diverse group of people, especially when a diverse group of *scientists* participate. And at the very least, these type of positive, fun scientist-student interactions leave a future generation of voters with a favorable impression of how science is done, so they can look critically at future scientific endeavors and help shape public support of science in a fair and positive way.

Astronomer Involvement in Their Local Community of Astronomy Educators and with National Organizations
White Paper (via email text)
jhl@u.washington.edu <jhl@u.washington.edu>

Suggestions
Currently I work as the Astronomy course coordinator (Astro 101-Stars, Galaxies and the Universe and Astro 150-The Solar System) with the University of Washington in the High School program. We have about 18 teachers who offer one or both of those courses at their high school for college credits. There are MANY of these programs now run by community colleges, 4-year and universities. Unlike most "college in the high school" programs, the UW program has won national accreditation. Non-accredited programs tend to have minimal support for the teachers offering the courses and the students taking them. I'd like to see more of my colleagues get involved with "college in the high school" programs. Astronomy is a perfect offering because it doesn't compete with Advance Placement and it is desirable for non-STEM majors to take to satisfy a college breadth requirement. Some colleges/universities like it (UW among them) because our in-person and online Astro 101 and 150 are totally fu!
ll. Frankly, it also helps with the "4 year graduation" rate. I'd be glad to write an article or to put something online about the advantages to astronomers and their departments of participating in a high-quality "college in the high school" program, the benefits to teachers and students and what we do to support UWHS Astro. The website for the UW program is https://sites.google.com/a/uw.edu/uwhs-astro-101/

I am also the Northwest Coordinator for the Center for Astronomy Education. Once a year I and about 2-3 other colleagues put together a one-day regional meeting for astronomy educators under the sponsorship by the CAE. No registration charge. We hold it on a Saturday. We have 15-20 minute presentations on projects, research, activities, new courses, informal education, etc. We require that presenters have some sort of audience interaction in their presentation (hands-on activity, think-pair-share and so forth). We have lunch. We do a lot of networking. People come from Washington (mostly), Oregon and Idaho for this. We usually get about 25 participants. The meeting really isn't much trouble. We divide up the tasks. One person hosts and arranges for lunch (either small charge or I have a small grant so it can be free), another handles the agenda and I make sure of publicity and other logistics. We all join in encouraging presentations. We've been doing it for about 10 years now. I'd encourage more astronomers to get involved with organizing such meetings. Again, maybe I and other organizers of regular regional CAE meetings could write something up and act as mentors to folks who want to do such a thing.

I also teach astronomy short courses for the Osher Institute at UW and other local entities that offer courses for adult audiences. These are usually 2-4 sessions of 2 hours each on some specific topic like Stellar Evolution, Galaxies, or Small Bodies in the Solar System. These are always well-received and the attendees are enthusiastic and very curious. I've noticed that the older students tend to broadcast astronomy information to their families and friends, so I think the impact goes beyond the 25 or so people who attend the course. I'd recommend more astronomers get involved in this sort of thing.

I've been involved with my state science teachers association, the Puget Sound Science Supervisors, Pacific Science Center, Museum of Flight and other education organizations for decades. I'd like to see more astronomers realize that working with national organizations (such as NSTA and ASTEC) is great, but there is a lot of impact to be had by working at the state and local level. Stories of how people got involved with formal/informal education and what sorts of things they have done might inspire others to get involved.

On the Use of Real Data
Karen Masters White Paper (via email message)

I wanted to transmit some of my views on this as a white paper. I have attached two publications which look into Galaxy Zoo and the Zooniverse citizen science projects in terms of the motivations of the users. We find that the users are overwhelmingly motivated by the contributions they are making to research through citizen science, and furthermore that the Zooniverse projects which are successful in public engagement metrics must also be successful at research output (we see no projects which are PE successes but not successes at research, while there are a few that have research outputs without being very successful at PE - all of this is described in more details in my paper which is attached).

I'm really passionate about this genuine research experience link, and I think we need to be careful to distinguish simulations of real research from real research. There's something intangible about authenticity which I think we need to do honestly.

I'm also keen on using real data in the classroom, so with my SDSS hat on, I want to talk about how we should be passionate about working on resources to help with the use of real astronomical data (SDSS or otherwise) for classroom or undergraduate labs. I think the work we've been doing with voyages.sdss.org is a good example of simplifying data access to real astronomical data. Skyserver.sdss.org also contains materials which do this (and has for over a decade).

Hawaii Student / Teacher Astronomy Research — AAS Education Taskforce whitepaper

Geoffrey S. Mathews[1], Mary A. Kadooka[1,2], James D. Armstrong[2], Michael A. Nassir[1], Karen Meech[2], Roy R. Gal[2*]

The University of Hawaii at Manoa (UHM) Institute for Astronomy's (IfA) Hawaii Student / Teacher Astronomy Research program (HI STAR) is entering its tenth year of training astronomy-enthusiastic high school students in research skills (Garland, Kadooka, Starkey, & Nassir 2008). The program has largely achieved its primary metric: the majority of students complete a long term research project.

1 Program description

Each year in HI STAR, a group of 10 to 21 high school students and 2–4 teachers attend a one-week residential Astronomy camp at UH Manoa. They learn core Astronomy content and measurement skills, and work on a brief research project with a professional astronomer mentor. After the camp, students are matched with a mentor to carry out a ∼6 month research project for submission to a local science fair.

Instructors and mentors include faculty, staff, and graduate students at the IfA and other units of UH Manoa (primarily the Department of Physics & Astronomy and the Hawaii Institute of Geophysics & Planetology). While HI STAR was categorized in the survey of extracurricular Astronomy programs presented in Fitzgerald et al., 2014 as a program that provides guided-inquiry experiences to high school students and teachers, it has evolved to culminate in many students designing and directing their own research projects while receiving the training and support they need to be successful (coupled-inquiry).

Through their mentors at UH Manoa, students have access to unprecedented observing resources; students have made use of data collected by

*[1] University of Hawaii at Manoa Dept. of Physics & Astronomy, [2] UH Manoa Institute for Astronomy

their mentors from observatories on Maunakea and elsewhere, and collected according to their own plans from the Las Cumbres Observatory Global Telescope Network of 2 meter and 1 meter telescopes (Shporer et al., 2010).

2 Metrics

In each of the past five years, 50–93% of students have completed long-term research projects, the program's primary metric.

However, students have achieved many other measures of success. Since its inception, HI STAR alumni have been awarded over $400,000 in scholarships and awards at science fairs. In each of 2015 and 2016, 5 alumni earned the right to compete in the International Science and Engineering Fair. A few have even contributed to peer-reviewed publications (e.g., Caballero 2013, Cabrera 2015).

An external evaluator in 2014 found that post-workshop HI STAR students report higher self-confidence in learning and doing science, as well as a better understanding of the steps involved in pursuing a STEM career and a higher interest in doing so. They also show improved knowledge of basic astronomy facts, the conduct of scientific research, and communication skills at both the team and presentation level.

HI STAR attracts diverse students from across the state of Hawaii. 60% of HI STAR students have been women, and nearly 30% are from underrepresented minority groups. Three students have had a learning disability.

Beginning with the current year's cohort, we will enhance our project evaluation by collecting detailed information on time spent on a variety of research activities, time on mentor activities, and metrics of research quality (drawing upon the categories of inquiry presented in Capps & Crawford 2013). We will also classify the types of activities used in direct teaching.

Comparison of practices and student outcomes will drive improvements in our explicit training in research skills and mentor and instructor preparation. We also anticipate the duplication of the HI STAR model in other locales and fields; the identification of key design elements and effective mentor practices will aid this effort.

3 Funding

Over its history, the ~$15,000 yearly direct cost for HI STAR was primarily supported by NASA outreach funds, with varying donations and smaller grants each year. In 2015, a half-size HI STAR workshop was conducted for Maui students; this was funded by a grant from the Air Force and a donation from the Maui Economic Development board. We are currently pursuing funding through donations, outreach grants, and through research grant broader impacts contributions.

The direct costs for student participation are low; housing and meals are approximately $500 per student, with most of the additional cost being housing for staff and volunteers from out-of-town and working lunches for all involved staff and volunteers. The program is currently run by three staff carrying out planning and design over the months leading up to the one-week workshop, with an additional 2 staff supporting implementation during the one-week workshop. An additional 3–4 volunteer instructors participate for 2 hours each at different points, and 6 volunteer mentors participate for up to 28 hours over the course of the one-week workshop. Long-term mentors contribute about 1 hour per week over six months.

The key long-term challenges for HI STAR are maintaining the essential funding for housing and meals and finding ways to compensate staff, mentors, and instructors. To date, most effort has been contributed on a volunteer basis, and it has been a challenge each year to ensure all roles are filled. Provision of compensation to staff, mentors, and instructors is a daunting long-term goal.

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The Right Balance

Liam McDaid
Astronomy Coordinator & Professor of Astronomy
Sacramento City College

As a graduate student at New Mexico State, I worked with Reta Beebe. She was the first person I encountered who had a specific and balanced philosophy for why universities exist. There were three things that all professors were responsible for: research, education and public outreach.Not surprisingly, the order I have listed them in was the order of priority she gave them. This leads to a widely recognized issue that I have seen spoken about many times but only a few solutions implemented for: the lack of incentive for improving education. As long as (most) prizes, tenure, hiring and other life-or-death decisions are made almost completely on the research record of an astronomer, education will always be a subject for lip service and no more. That needs to be fixed institutionally and it needs to be fixed by the astronomy community. Any solution imposed from outside would be resisted and ultimately will fail.

When I meet young astronomers today, it is clear that they get Beebe's message. Many of them already have done or are doing public outreach on their own time. This is heartening yet also worrisome at the same time. As the Astronomy Coordinator for Sacramento City College, a large portion of my workload goes toward public outreach. This is work that requires me to work many nights, but I am paid for it. If astronomers are doing public outreach *gratis* now, it will be presumed by those in authority that this should continue. The internet has proven that there is no limit to what people expect to get for free. If we are a profession, and those who practice astronomy are professionals, then they should expect to get paid for their work as that is the true definition of the word "professional:" one who does not work for free.

While I have not done research for decades and never felt it was as personally important to me as letting the public know what has been done with their tax dollars and making it clear what it means and why it matters, I recognize its primacy in any discipline. Yet an astronomer who cannot explain what they are doing to a layperson should not get a pass based on their grant funding capacities or abilities. We are all at times called upon to let the outside into our world and it is central to what astronomy does even more so than the other sciences. The promotion/reward structure should reflect this. Along with education, a public outreach component should be expected and rewarded. We may also discover that some other issues our profession faces, such as a lack of diversity and gender or age imbalances might best be addressed at the grassroots level by engaging directly with the public.

One may debate with Beebe over what the priorities are in the three legged obligation that astronomers have, but she recognized the importance of all three decades ago. It is time that all astronomers accept this obligation and start molding the process for future astronomers so that this becomes implicit in the profession so that all may benefit from our work.

Concept White Paper — Prof. Daniel H. McIntosh (UMKC)
Freshman University Pre-STEM Program — July 24, 2016

A role model program for increasing numbers from underrepresented groups that successfully earn physical science (STEM) university degrees.

I. Summary

Lack of diversity recognized as a major, persistent issue among all STEM stakeholders. Increasing participation is a challenging socio-economic issue; e.g., students from poorest family quartile are half as likely to be high achievers compared to those from upper family income quartile. An inclusive and supportive 1-year pre-STEM program that "prepares a diverse workforce for the careers of tomorrow" is in line with all 5 major themes of the UMKC Diversity Strategic Plan.

II. Identified Need

High school seniors from underrepresented groups tend to (1) achieve lower scores on standard metrics for acceptance into STEM degree programs or even college, and (2) to be particularly underprepared in math and science education compared to traditional STEM major freshmen. These issues result in (1) low diversity in recruitment, and (2) discouragement in critical gateway courses for those who actually get a foot in the door. Indeed, researchers identify people of color, women and low-income students as those most at risk for dropping STEM degrees. KC has a strong base of STEM companies, but our fast-growing computer, engineering, and life sciences industries struggle to find qualified employees. According to IPEDS and CIP code data, just 14% of local college graduates earn STEM degrees, and completions by under-served students are flat/declining over past 5 years.

III. Solution

A 1-year program designed to help interested but underprepared freshman transition into, and succeed at, achieving a traditional STEM BS degree. Design a set curriculum that engages students in solid STEM conceptual learning (role model ASTR 150/155), gets them caught up in math (thru pre-calculus) and basic sciences, helps them navigate college life, and aids their development of career-oriented thinking. Include supportive network of UG mentors to help students succeed, and inclusive discussion groups (e.g., Astro Hour) to strengthen cohorts and build community centered on common goals.

IV. Why this solution?

UMKC is an urban university with exciting STEM opportunities/programs, a strong community engagement record, a diverse student body, and a commitment to diversity and inclusion. A loose collaboration of KC STEM proponents already exists with similar goals (e.g., A Bridge to the Stars network).

V. Conclusion

Offering this to the 25-50 students who apply annually to UMKC STEM programs with modest ACT scores will significantly increase diversity among STEM majors, the rate of successful completion of STEM BS degrees in 5 years, and increased diversity among STEM degree recipients. Promoting and facilitating the success of motivated yet unprepared students will increase retention and success in STEM degrees, the gateway to successful careers in the fastest growing economic sector.

Daniel H. McIntosh

A Bridge to the Stars: High School-to-College Pipeline to Increase STEM Diversity

A role model program for increasing numbers from underrepresented groups that pursue physical science (STEM) university degrees.

Executive Summary

Increasing participation from underrepresented groups in the STEM workforce, especially in the physical sciences, remains a serious challenge and a top priority for both the National Science Foundation (NSF) and NASA. This high school-to-college pipeline will increase STEM diversity in Kansas City through a 3-tier engagement program of innovative learning, mentoring and research training opportunities for underrepresented and underprivileged 15-21 year-olds. These opportunities are all housed at the University of Missouri-Kansas City (UMKC), an urban research university. The opportunities are (1) enrollment for high-school sophomores/juniors (*Bridge Scholars*) in a highly-effective introductory astronomy course at UMKC for college credit; (2) internships for UMKC undergraduates (*Bridge Mentors*) to mentor incoming *Scholars* and help them succeed in a freshman university STEM course; and (3) enrollment for select *Scholars* plus community-college and UMKC undergraduates (*Bridge Research Trainees*) in an innovative summer training program to gain research experience plus technical communication plus 'big data' skills. This program builds from a series of novel, signature programs established over the last six years at UMKC by Dr. McIntosh, an award-winning physics/astronomy professor and astrophysicist. The short-term goals of the proposed 1-year program are (a) to significantly increase the annual number of underserved youths participating in these ***existing*** opportunities from 5 to 18 *Scholars*, from 2 to 6 *Mentors*, and from 1 to 10 *Research Trainees*, and (b) to strengthen and expand the ***existing*** community of local public-school teachers/administrators through formal partnerships that are necessary to sustain a viable annual pool of high-school students entering the pipeline. The impact of these goals will be improved participant statistics to demonstrate the success of the program through long-term (min. 5-year) tracking, a sustained increase in the number of participants moving through all three legs of the program during the next five years (increase the number of *Scholars* => *Trainees* => *Mentors*), and growth in the numbers of traditionally underrepresented students gaining research assistantships, declaring majors and achieving degrees in STEM (especially physical science) fields nationally. The proven success of A Bridge to the Stars will leverage additional funding to maintain the program locally, and more importantly, it will enable the long-term goal of establishing the program nationally as a model for other, especially urban, institutions to initiate or imitate. Existing strategies have failed to increase STEM diversity despite clear federal mandates. To meet the challenge in the coming decades we must have engaging, high-impact, secondary school-to-college pipelines that increase diversity in all STEM fields in every urban center of the country.

Gemini Observatory's "Practical" Vision for Local Outreach

By Peter Michaud

There are myriad principles and philosophical foundations used to justify astronomical outreach and education. However, few of these have strong practical foundations that will, as the cliché goes, "put food on the table."

At Gemini Observatory our local outreach programming in Hawaiʻi and Chile is rooted in STEM career awareness and providing opportunities and experiences that broaden students' futures. Ultimately, our vision is simple – to increase participation by local residents in astronomy's STEM-centric workforce, and yes, put food on tables throughout our host communities!

A Focus on Opportunities

With two sites, one on each hemisphere, Gemini strives to unify our outreach and educational programming around a common vision that is relevant and appropriate for both host communities (in Hawaiʻi and Chile). Our focus on student success in pursuing opportunities in STEM careers has proven to resonate strongly with parents, teachers, and most importantly, students on both hemispheres.

Implementing this vision is infused into all aspects of Gemini's educational programming and communications activities, including social, electronic and traditional media. However, this vision is most profoundly manifested in our flagship community outreach programs: Journey Through the Universe (in Hawaiʻi), and Viaje al Universo (in Chile).

While Gemini's education and outreach focuses heavily on our local host communities, we also extend our reach beyond our local shores. Throughout the year we offer a large number of internship opportunities to both local and non-local students and early-career professionals.

Implementation

Two core principles guide in the implementation of Gemini's host community outreach programming: 1) broad staff involvement; and 2) organizational and community partnerships.

Of our two flagship programs, "Journey" and "Viaje," both exemplify these principles to their core. However, for the following case study, we

Gemini astronomer Andre-Nicolas Chene shares his passion for astronomy with Hilo students will focus on the *Journey* program in Hawai'i since it is the longest running of the two programs, and is also the basis for the Viaje program in Chile. This is followed by another brief case study of Gemini's career awareness resources that augment all of our outreach programming.

Maunakea observatory staff participate in a STEM career panel for local students and teachers as part of the Journey Through the Universe program.

Case Study I: Journey Through the Universe

Celebrating its 12th year (2016), the annual Gemini-led *Journey* program is a continuation (and adaptation of) a program originally led by the Challenger Center and hosted in 13 US communities. For more background see: http://www.gemini.edu/journey

In its current (Hawai'i) incarnation, the multifaceted *Journey* program consists of hundreds of classroom presentations by over 50 staff from all of the Maunakea observatories, participation by (over 40) dozens of community partners (institutions, businesses, and individuals), and multiple special educational events and workshops for K-12 schools and families. Capturing the essence of the program, and the energy it generates, is well beyond the scope of this document, but the following are highlights from the 2016 program:

• Presentations by observatory staff to over 300 Hawai'i island classrooms (see tinyurl.com/zhx2htg for poster showing observatory participants and partners);
• Career panel presentations to high school students by observatory staff on diversity of careers, personal stories, and opportunities;
• Support by NASA SSERVI, University of Oregon, the Institute for Astronomy, Maunakea observatories, University of Hawaii at Manoa and Hilo.
• Recognition by state and local governments and local/national media.

Case Study II: Career Awareness Brochure and Videos

Augmenting all of Gemini's outreach programming (local and beyond) are our career resources. At the core is a large-format brochure (versions in English and Spanish) featuring short profiles of selected staff with a companion website presenting personal interviews. Staff profiles are balanced for ethnic and gender diversity as

Students in Chile learn about observatory STEM career options with the Gemini career brochure.

well as underrepresented minorities. While this introduction to observatory careers targets students it has proven extremely popular with teachers and parents as well.

We are currently working on version 2 of this brochure and website, as well as the production of more in-depth profiles of selected positions. An electronic version of the brochure and a link to the videos can be found at:
http://www.gemini.edu/careers

Finally, the Challenge of Assessment

Outreach programs like those described in this document, are notoriously difficult to assess effectively and with actionable outcomes. While Gemini (and our educational partners) continue to perform simple assessment of teacher satisfaction, program growth etc., measuring the real impact on students, especially their decision to pursue STEM careers, is several orders of magnitude more difficult.

Programs like the Akamai Workforce Initiative observatory internship program (with whom we partner) have been successful in performing long-term longitudinal studies of participating students. However, given the open environment of our student and teacher programming, tracking our impact presents different challenges. We are currently exploring how to better track our program's impact on students and teachers, from relatively simple pre-post attitudinal changes, to the elusive goal of tracking our impact on future career choices of students. We see this type of assessment as one of the greatest challenges in our field and feel that our professional community needs to work together more effectively in the area of assessing our long-term impact on society and public engagement in the endeavor of astronomy.

Astroinformatics and Astronomy of Tap

Demitri Muna White Paper (from email text)

I'd like to first discuss education. It's no secret that there is a large, mostly unmet demand for astronomers interested in learning what has recently been termed "astroinformatics". This includes learning Python, foundational programming skills, data visualization, version control, machine learning, and many more topics. All of these skills are important today and are becoming increasingly so. The problem is that early career astronomers are often not taught even basic programming skills. The story of the grad student, having never programmed before, being given an existing C or Fortran code and asked to modify it while learning to program at the same time is an extremely familiar one.

I have always had an interest in software development and developed my skills parallel to my research, frequently to support it. From grad school, I saw my peers struggle to do simple work with software or unable to perform more complex tasks. I felt that if they could give me just five days, I could make their life easier. This led to the creation of my SciCoder workshop in 2010. Held annually for about 35 students each time, it has sold out every year. Feedback has been extremely positive, and many professors send new students each year. In no way, however, does this meet demand. Software Carpentry offers one to two day lectures, but I very frequently from attendees that this is not enough time to build the knowledge or confidence to use the material presented. Hack days are fun for those who have high-level programming skills, but often cause anxiety to those who do not.

As recently as last year I attended a session at AAS where students expressed a strong desire to learn these skills, recognized as essential for their work in research or professional development for those that move on to industry. Many teachers recognize this, but they themselves are not experienced with these skills to teach them. Further, they commented they have no outlet to learn them themselves.

I have the experience and enough materials to turn SciCoder into a course and/or a book. However, I have come to realize that doing so would provide no benefit to me. People expect such a course to be available for free, and while they and not wrong I am in no position to devote the enormous amount of time for no gain. None of the jobs I have applied for in the past three years (strongly in the area of astronomical software development or data science) have expressed any interest in the educational benefits I offer, so this has not benefitted my career. (Except for name recognition among early career astronomers who, sadly, can't hire me.) And as is common knowledge, writing a book takes an enormous amount of time and effort, but pays very little.

The bottom line is that there is a clear, articulated need for this kind of education to be made available for many years now, but there is no career benefit to provide it, nor is any institution willing to take a leadership role to develop it. I have identified and tried to provide this instruction because I enjoy it and for the enthusiastic feedback I have received, but have done so in my own personal time and expense. This *must* become a priority in the community, and it needed now, today, not after further years of discussing the need without action. I am willing to be a part of the solution (in fact, I feel I have been since 2010), but for myself and others who are willing to be, the career benefits are not there.

The second area I would like to comment on is in public outreach. Meg Schwamb started Astronomy on Tap (http://astronomyontap.com) four years ago in New Haven, then New York City. This is an outreach effort to bring astronomers to local bars (and other informal atmospheres) and give brief lectures to the general public followed by a lengthy Q&A. I started the first "franchise" in Columbus, Ohio. Since then, there have been about 150 events worldwide over the past three years, and we estimate we've presented to 10-20,000 people. Events are frequently sold out, and we constantly receive requests to hold events in cities where we don't have a presence. All of this has been accomplished with no funding; it has been a labor of love for the dozens of astronomers (mainly organized by students) involved, and all out of pocket. By any measure this has been an unqualified success. It is more than reasonable for the astronomical community to help fund efforts like this, but we have either been turned down or are not aware of where we might be able to get funding.

Bottom line, in my experience public outreach and astroinformatics education are areas that area valued, but receive little to no official support. Efforts that exist are largely done as a labor of love for the science, but (particularly as these activities do little to further one's career), it's unfair that they not be supported.

Thank you for reaching out for my thoughts on these matters, and I'm happy to discuss them further or answer any questions.

University of Virginia

P.O. BOX 400325
CHARLOTTESVILLE, VIRGINIA 22904-4325

Department of Astronomy

ROBERT W. O'CONNELL
Tel. [434] 924-4887
Email: rwo@virginia.edu

29 May, 2016

Charles Liu and Gina Brissenden
AAS Education Task Force

Dear Charles and Gina:

Thanks for the opportunity to comment on the goals for the AAS task force on education. Here are some thoughts on a few topics.

Professional Development for Graduate Students

This semester I taught a seminar on professional development for first and second year astronomy graduate students (`http://www.faculty.virginia.edu/rwoclass/astr8500`). This is the first time we have offered such a course. I believe many other departments are planning to incorporate such elements formally in their graduate programs.

I found that it was hard to locate current information on the astronomy job market. The AIP website hosts a number of excellent statistical studies of professional astronomy, but these tend to be five or more years out of date. I was disappointed at the lack of statistical information about jobs or demographics on the AAS site. Despite references to official summaries of postings in the AAS Job Register in both the Metcalf (2008: PASP, 120, 229) article and the 2010 decadal survey, those are currently absent from the AAS site. It would be a valuable service for the AAS to provide up-to-date statistics on Job Register listings similar to those in Metcalf's Table 2 and, if possible, to add information on whether and how those vacancies were filled.

There also should be more guidance for PhD's who are looking for jobs outside astronomy. It might be possible to arrange with the AAS's corporate sponsors to hold workshops at meetings and/or to open other channels for advice on navigating the broader career universe.

The AAS/Careers site also needs some attention. Much of the information there is either dated or not specific to astronomy. It would be good to post thoughtful articles on professional and career issues solicited from knowledgeable astronomers.

By the way, the topic in our seminar course that elicited the most immediate interest from the students was time management, an important subject for anyone who is crossing from the student to the professional world.

NSF-Sponsored Outreach/Educational Programs

The "broader impact" provision for individual NSF proposals has led many astronomers to undertake public outreach programs with which they otherwise would not have become involved. I am entirely sympathetic with NSF's goal here. But as it stands, the provision does not realize concrete, long-term gains because of the absence of any means of making the finite if small gains in each of hundreds of individual programs cumulative or adding to the national base of expertise in these areas. Each year, scores of awardees are reinventing the wheel because they have no idea what others have done or are doing. Rather than "letting a thousand flowers bloom," NSF is merely piling up thousands of dead flowers when the grants run out.

The least the AAS could do would be to compile a public directory of the proposals for "broader impact" outreach/education from NSF awardees together with brief reports on the extent to which the realized programs met the intended goals. I understand that PI's would have to voluntarily provide such information, but with a little moral suasion from the AAS, I'm sure most would be happy to do so.

Outreach to potential scientists

If we want to encourage bright young people to become astronomers, we need to recognize that it's very difficult for us to locate them (at a density of perhaps 1 PhD candidate per 50 elementary schools) but it's easy for them to locate the AAS on the Web. I think the critical age range is 9-12, when thoughtful kids are first starting to seriously explore career options. We need to provide more good advice aimed directly at those ages regarding choices in academics, good resources on the Web, and other options that will involve them in science beyond their schoolwork. (An obvious near-viral example of the latter is astrophotography and videography.) At the moment, the AAS Education pages are directed at older students or parents.

Educational Reform and Faculty Workloads

Astronomy professors are routinely inundated with proposals for classroom or curricular reform and advertising for commercial teaching packages. Aside from the sheer volume of material, one of the main problems in evaluating it is that there is rarely any indication of how much faculty effort will be involved in implementing the proposals or the opportunity costs they entail. A salient example: the surprising fact emerging from the widely promoted MOOC experiment that it usually takes 50-100 hours of faculty time to produce a single hour of instructional video.

Faculty time is the most valuable asset available to any university. Reformers and advertisers are irresponsible when they don't address the impact of the changes they are promoting on faculty workloads, which is, of course, hard to establish in the absence of well designed and documented pilot programs. The main goal of teaching reform should be to increase the efficiency of our teaching effort — i.e. to improve outcomes without increasing the invested effort.

The AAS Education Committee could help in two ways: first, by encouraging explicit consideration of faculty workloads and teaching efficiency in educational research projects and publications. Second, by encouraging a "Consumer Reports" approach, where independent, objective analysis of educational reform programs and commercial products is made available to the end users.

Sincerely,

Robert W. O'Connell

J. D. Hamilton Professor
of Astronomy, Emeritus

Enabling instructors as partners in undergraduate instructional change

Authors: Alice Olmsted (Univ. of Maryland) and Tim Chambers (Univ. of Michigan)

As a community, we have made great strides in improving undergraduate astronomy education. Education leaders have spent significant time and energy developing research-based instructional strategies in astronomy and physics, which can greatly improve student outcomes over traditional lecture [1–3]. Professional development workshops have proven to be a very effective mechanism for raising awareness of research-based instructional strategies, and faculty are often motivated to try these strategies, and do try them, after they have learned about them [4]. However, many undergraduate instructors still make limited use of research-based strategies and principles in their teaching in the long term, which suggests that there is significant room for further growth [4].

Research on undergraduate instructional change in STEM can provide some insight into what might be limiting faculty's use of education research. The primary mechanisms we have used to promote instructional change are largely targeted at encouraging individual instructors to adopt existing strategies, and are short-term interventions (e.g., workshops) [5]. A sole focus on short-term dissemination either assumes that once instructors learn about these prescribed strategies, they will be successful in their classes, or that instructors have and will spontaneously seek out other support structures in their home institutions. However, many instructors do struggle to persist in using these strategies, which implies that these assumptions are at least somewhat flawed. Moreover, while many workshops strongly support the adoption of research-based instructional strategies, instructors often want or need to adapt and modify these strategies to fit their local contexts [6]. This mismatch in expectations between physics and astronomy education researchers and instructors can create negative relationships that make instructors feel like outsiders in the change process, e.g., physics education researchers are perceived to be dogmatic and unsupportive of the kinds of changes instructors want to make [6].

In astronomy specifically, many of our members are dedicated to making our community more equitable and inclusive of all people (e.g., the Inclusive Astronomy Conference), yet we have spent little effort critically examining the experiences of undergraduate astronomy majors who are often active contributors to our discipline and might become the next generation of astronomers. It has been well-documented that undergraduate women and other underrepresented populations of students disproportionately switch out of STEM majors, and that "poor teaching" has been a primary concern that both contributes to students' decisions to switch and degrades the experiences of students who do not switch [7]. We know that research-based instructional strategies can improve students' experiences and retention over traditional lecture in general [3,8,9], but there are almost no studies that explore what these strategies might look like in our majors classes. Beyond this, there are still many aspects of promoting equity in the classroom are not well-understood within the astronomy and physics education research communities [8,10–13], and we could all greatly benefit from increased involvement of instructors with a diversity of expertise.

One path forward is to put in place new support structures that would cultivate future leaders in instructional change. By supporting instructors in learning how to adapt, modify, and re-envision research-based instructional strategies in fruitful ways, astronomy and physics departments could develop more embedded local expertise in education research that could have long-term payoffs. Instructors already have potentially rich knowledge of their students, their local constraints and resources, and the course content that would be assets in instructional change efforts. For example, instructors at minority-serving institutions and community colleges likely have unique insights into their students' experiences that the developers of many instructional strategies lack [10,11], while faculty at research institutions might have deep knowledge in a particular sub-discipline of astronomy that would help them to articulate learning goals and design activities that encompass foundational knowledge and skills in that content area. At the same time, we know that instructors likely have much to learn about education research, and often report that they lack the time and energy required to change [14]. Because of this, we think that instructors could greatly benefit from collaboration with knowledgeable others, and agree with those who have argued for the potential in team-based approaches to instructional change where multiple people collaborate to develop a shared product [5]. We also agree that having instructors partner with people who are able to help them discover and incorporate education research results in their classes is likely a critical piece of what can make these efforts successful [15–17]. We think that many people--undergraduates, graduate students, postdocs, staff at teaching and learning centers, and education research faculty--could possess or develop this useful expertise and thus contribute to instructional improvements [15–18].

To this end, we propose that a subset of the AAS education funds should be used to create a mini grant line for undergraduate astronomy instructors (a few grants per year of up to ~$5K). This grant line would provide resources for instructors to form small instructional teams (e.g., hiring an undergraduate or graduate student and forming collaborations with other local instructors who have similar goals) to pursue specific challenges in undergraduate astronomy education that are related to issues of equity and/or the teaching of astronomy majors. Preference could be given to instructors with fewer local resources available. Applying for this grant would require instructors to define concrete, achievable outcomes, to seek out local supports and expertise, and to commit to pursuing these goals with others over the course of a semester. Grant recipients would be required to share their work with others at the conclusion of the project, potentially in the form of a newsletter article and/or a presentation at a AAS meeting, which would shine a spotlight on members of our community who are potentially less "expert" in education research but doing valuable work in their classrooms. We also think that cultivating change agents with these small grants could have ripple effects in the long term for the astronomy education research community or their home departments. Individual faculty members can be powerful advocates for change in their own departments [16], and obtaining small grants could be a pathway for faculty or students to become involved in education research more formally. Students who work on these teams could gain valuable experiences in educational design that could help them to pursue future career opportunites. Furthermore, the instructional areas that would be funded are not well-explored, therefore even modest research contributions could be highly valuable to the astronomy education community.

Finally, we note that astronomy education researchers at any level currently lack a AAS-sanctioned place to publish peer-reviewed work. If we want to foster a community of educators who are dedicated to improving astronomy education in a thoughtful, research-informed way, need a space that is officially recognized by our professional community where those who do scholarly work can share their findings. We encourage the task force to consider possible models that could support this, such as partnerships with journals in similar disciplines, or an astronomy-specific journal that publishes a broader range of articles than the Astronomy Education Review.

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The Need to Understand Success in Preparing the Next Generation of Astronomers

Authors: Alice Olmsted (Univ. Maryland) and Edward Prather (Univ. Arizona)

There is a dearth of research in astronomy about how our majors courses are taught and what students are learning in them. Departments are routinely asked by institutional administrators to report learning goals for their academic programs and provide evidence to demonstrate whether these outcomes are being assessed and met. Not only does the astronomy community lack research on the learning of its majors, there is no research on whether departmental learning goals (and pedagogical approaches) actually match what students need to be successful in their future careers. Because of this, departments are inherently limited in their abilities to accurately report student gains to their institutions or assess their own programs. The AAS is uniquely positioned to obtain this information by surveying astronomy departments (what is being taught) and recent graduates (what skills, knowledge, or abilities do they currently use in their jobs, and what aspects of this were improved through participation in astronomy programs). Trends in the alignment (or misalignment) between astronomy majors' needs and their undergraduate preparation could feed back into the astronomy curriculum and influence both what skills are targeted and, by extension, what pedagogical strategies are used, and provide more robust ways for departments to report on the success of their undergraduate programs and instructional approaches.

White Paper for the AAS Education Task Force

Preparing Students for the 2017 Total Solar Eclipse Across America

Jay M. Pasachoff
Chair, IAU Working Group on Solar Eclipses
member, AAS Eclipse2017 Task Force

We have a tremendous opportunity for education for students at all levels—preschool through university—when all the United States and adjacent countries enjoy a partial solar eclipse on August 21, 2017, with a 70-mile-wide path of totality crossing many states, including parts of Oregon, Idaho, Wyoming, Nebraska, Kansas, Missouri, Illinois, Kentucky, North Carolina, Tennessee, Georgia, and South Carolina.

Mapmaker Michael Zeiler has found:
12 million US residents live within the path of totality (3.75% of total population)
47 million US residents live within 100 miles of the path (14.4% of total population)
88 million US residents live within 200 miles of the path (26.9% of total population)
128 million US residents live within 300 miles of the path (39.0% of total population)
174 million US residents live within 400 miles of the path (53.3% of total population)
222 million US residents live within 500 miles of the path (68.1% of total population)

Historically, students and the public have been given misleading or false information that it is unsafe to watch the eclipse to keep from going blind, and even that special eclipse-glasses are unsafe. Actually, if students are given false information like that, when they soon speak to friends who tell them how glorious totality was, they then won't trust officialdom about other health news or other matters of public importance. So it is important for us to spread accurate information through the schools and other mechanisms.

Several of us have been doing so. The AAS is asking for volunteers, and the 40+E group (40-year-members + emeriti) is a likely participant. Andy Fraknoi and Dennis Schatz have done a nice eclipse book with exercises for the National Science Teachers Association. Charles Fulco is conducting workshops. I am giving the keynote at the AAPT in Atlanta in February 2017 and organizing an AAAS session for Boston, also in February 2017.

I hope that the AAS Education Task Force takes on education about the 2017 total solar eclipse, how to view it safely, and how inspirational it can be for students to view it and to realize that scientists can predict such things accurately.

Some resources include my IAU Working Group on Eclipses website: eclipses.info, which has links to many other sites. Zeiler's site is: GreatAmericanEclipse.com.

Astronomy4Kids:
An online video series for young children suitable to formal and informal learning environments

Richard L. Pearson III, PhD
University of Denver, rlpearson.the.third@gmail.com

The Need for Astronomy4Kids: Much discussion and research has been conducted on the significance of early childhood learning. The general trends show that for language[1], mathematics[2], and general science[3] there are significant benefits to reaching a child as early in their life as possible. When concepts are introduced to a child at a young age, that child is better prepared when the concept is re-introduced in its entirety later on. The AAS has embraced this with the Astronomy Ambassadors program, to help spread the word about organizations teaching and reaching out to the community. The National Science Foundation has also recognized this importance by implementing the STEM Learning and Research Center to "build capacity,... magnify the results,... [and] deepen the impact of the [Innovative Technology Experiences for Students and Teachers] program"[4]. **Despite the many resources available in general, the education outreach available to the *youngest* learners (under the age of 8 or those from pre-school to about 2$^{\text{nd}}$-grade) is seriously lacking.**

The Astronomy4Kids video series fills this void of effective and engaging education tools for early childhood learning using online instructional videos. In each video, I explain a single, simple astronomy concept that is typically paired with an activity to help engage the viewer, prompt him/her to explore, and extend their knowledge to better understand the universe around them. The material is presented in a succinct, one-on-one manner, following the principles of the founder of preschool education video, Fred Rogers. The hope is to give young children access to an expert astronomer who can explain things simply and sincerely. We believe presenting the material in this manner will make it engaging for even the youngest scholar and available to any interested party.

Current status: We have currently established an Astronomy4Kids YouTube channel, Facebook page (`www.facebook.com/astronomy4kids`), and Instagram handle (`@astronomy4kids`). The publication of the video series through the free online platform of YouTube, enables broad access to the content and a myriad of uses. The videos and activities are designed to be used in both formal and informal education settings, including, but not limited to an in-school STEM activity, a home-school setting, after-school programs, summer camp programs, or at home. We have the goal to reach any interested child, including under-represented areas that have a harder time accessing and/or funding similar programs. The videos can be watched by a child individually, in a classroom setting, or with an adult. Additionally, we are in the preliminaries of developing tutorial videos and supplemental materials which will provide educators and caregivers with follow-up questions, age-appropriate variations on the activities, and optional worksheets.

The first video of the series was released in September 2015 and there are now over 2,000 views of the—presently—seven videos (see Figure 1 for example images). Thought we are still evolving and seeking monetary support to further enhance and streamline the production, we have received many positive reviews as we continually enhance the Astronomy4Kids product.

[1]Garcia-Sierra, A., et al. *Journal of Phonetics* (2011), doi: 10.1016/j.wocn.2011.07.002

[2]See the National Association for the Education of Young Children position statement at `https://www.naeyc.org`

[3]Duschl, R. A., Schweingruber, H. A., Shouse, A. W., editors, *Taking Science to School: Learning and Teaching Science in Grades K-8*, National Academies Press (Washington, D.C.), 2007

[4] Defined in the mission of STELAR, found at `stelar.edc.org`

Looking forward: Our specific goals for Astronomy4Kids are to produce videos on a more frequent basis, to disseminate interest and enthusiasm of the project on our social media platforms, and to develop the supplemental materials discussed above. Additionally, we would want to connect with a professional videographer to further improve the production quality. We feel there are endless possibilities with this format—including extending it to other fields such as engineering and general physics—if we can connect with the right organization. Regardless, Astronomy4Kids plants astronomical seeds, nourishes excitement about space, and prepare minds for science literacy. The structure of Astronomy4Kids is a cost-effective method to reach even the youngest child within formal and informal environments of learning.

(a) Example of a YouTube video thumbnail


(b) Dr. Richard Pearson filming

Figure 1: Images from production of the Astronomy4Kids video series. The first shows the image used to represent the video produced for counting the number of moons in the solar system. The second shows an image while filming a video about eclipses.

Establishing a Presence on YouTube for Formal and Informal Astronomy Education

Viranga Perera[1*] **and Sanlyn Buxner**[2]

[1]School of Earth and Space Exploration, Arizona State University, PO Box 876004, Tempe, AZ 85287-6004, USA.
[2]College of Education, University of Arizona, 1430 E. Second Street, P.O. Box 210069, Tucson, AZ 85721, USA.
[*]viranga@asu.edu

ABSTRACT

YouTube is a popular destination on the web and even though it is primarily a platform for entertainment, it has many science videos that have been watched millions of times. Even though science videos are popular, there are a number of reasons why science educators might be hesitant to use and endorse the platform: the quality and accuracy of the videos on YouTube, watching videos being a passive learning method, and viewers acquiring incorrect ideas about the nature of science. Perhaps due to all or some of these reasons, the American Astronomical Society (AAS) does not have a significant presence on YouTube. We propose here that the AAS should establish a channel on YouTube for the purpose of both formal and informal astronomy education. A reputable organization such as the AAS producing high-quality, up to date, and accurate videos will greatly benefit learners who seek astronomy-related information on YouTube. In addition, we list a few recommendations for the video creation process.

Introduction

YouTube is a video-sharing website that launched in 2005 and is currently the second most visited website in the world.[1] The large collection of television clips, original short films, movie trailers, and music videos make the website primarily a destination for entertainment; however, there is a substantial collection of educational science videos that make the website also a destination for both formal and informal education. The popularity of these videos is a testament to the great effort of the channel creators to produce high-quality, clear, and entertaining videos. The popularity is also telling of the market for science videos by the public. For example, the channel Reactions[2] produced by the American Chemical Society (ACS) started in early 2014 and now has over 18 million views and over 150,000 subscribers. In comparison, the American Astronomical Society (AAS) YouTube channel called AAS Press Office[3] has only one video. The nearly hour-long video titled "AAS Online Press Conference: Extreme Solar Systems III" has been viewed 608 times. It is recommended here that the AAS should establish more of a presence on the platform for both formal and informal education purposes.

Formal Education

Formal education is education that takes place within academic institutions such as schools, colleges, and universities with a mediator such as a teacher, an instructor, or a professor. It has been noted that traditional, passive lectures are not effective.[4] Instead, researchers have suggested that active teaching methods such as think-pair-share, lecture-tutorials, and ranking tasks be used because students' average exam and concept inventory scores improve as a result.[5–8] In addition, there have been suggestions to use a "flipped" classroom. In "flipped" classes, instead of getting a lecture in class and doing assignments by themselves at home, students watch video lectures at home prior to the class period and they work through assignments in class with the instructor present for help.[9] Furthermore, video lectures could be supplemented with videos of worked problems that are uploaded to YouTube[10] and videos could be used for makeup lectures.[11] Others have also suggested that YouTube videos could be used for training nurses[12] and in anatomy education.[13] Videos are being used in formal education; therefore, it would be advisable for the AAS to produce videos related to astronomy since it could ensure that the videos are of high-quality, up to date, and accurate. This would help instructors who would like to use a "flipped" classroom from having to make their own videos or from having to rely on videos that have not been peer reviewed.

Informal Education

Informal education is education that takes place, usually, outside academic institutions at the discretion of the learner, based on their own interests, without a mediator who directs the learner towards specific learning objectives. Informal education is important for several reasons. First, only a fraction of students' time is spent in the classroom and when considering that most people are only in an academic environment for a brief period of their lives, it is important to make educational material available to them outside of formal education. Second, informal education is intrinsically motivated, which aids learning and makes it likely that the person engaged in the learning process will become a life-long learner. For informal science education on YouTube, there are a number of channels such as AsapSCIENCE[14], Healthcare Triage[15], It's Okay To Be Smart[16], Kurzgesagt–In a Nutshell[17], MinuteEarth[18], MinutePhysics[19], Reactions[2], SciShow[20], Sixty Symbols[21], Veritasium[22], and Vsauce[23] to name some of the popular channels. These channels not only have high-quality videos that have been viewed millions of times, they also have a great number of subscribers. Of the channels listed above, Vsauce has the most with over 10 million subscribers. Though many scientific concepts are explained well on these channels, since these channels are not peer reviewed, it is possible that some explanations are incomplete. Furthermore, due to the nature of the YouTube platform, short videos lasting less than 10 minutes are fragmented in a way that an informal learner might not be able to garner context and the holistic nature of science. Therefore, it would be advisable for the AAS to produce videos so that viewers can be more confident in the information they are receiving. It would also be helpful to produce videos with a goal of making connections between various scientific concepts.

Discussion of Potential Criticism

There is likely to be skepticism about putting personnel and financial resources behind making YouTube videos for formal and informal science education. Therefore, it is important to address concerns that people may have about the effectiveness of this strategy and to discuss criticism of online science videos in general.

Accuracy and Quality of Videos

One concern would be the accuracy and quality of videos on YouTube for science education purposes. Though more research is necessary in this area, researchers have cautioned, as examples, that the quality of videos on first aid treatment due to burns are unsatisfactory[24] and that information on prostate cancer is not reliable.[25] Since YouTube has been suggested for medical training, such as for training nurses[12] for example, it has been noted that instructors should only assign videos as supplementary material for clinical skills education once they have vetted them for quality.[26] This is a good practice, especially on YouTube, since unlike Wikipedia, it has no editors to control for quality and anyone is free to post videos. As previously mentioned, the solution here would be for reputable organizations such as the AAS to post high-quality, up to date, and accurate videos like the ACS does so already.

Passive Education

It could be argued that watching YouTube videos is a passive method of learning and therefore is not as effective as active learning methods as mentioned previously. However, YouTube videos allow for comments by viewers and for others viewers to reply to those comments. This process makes the platform more of a social interaction. For example, the SciShow has an episode titled "So what IS the Higgs boson?" that was uploaded in early 2012. One person asked the following question in the comments section: "So then if the Higgs Boson exists or rather when we find it. What makes up the Higgs particle [sic]." Another person responded, "I believe it's an elemental particle, not made up of anything really, kind of like the electron. But I'm not entirely sure." The comments section allows for users to make learning more of an active process by posing and/or answering questions.

YouTube comments can be very negative, for example, when female presenters are judged more harshly than their male counterparts.[27] However, it has been shown that comments that are made on YouTube science videos can convey feelings, beliefs, and memories about physics problems, textbooks, and classes.[28] It is argued that these comments should be used to make better physics problems that are less artificial and peculiar. In addition, work has also suggested embracing arguing, which even though an essential part of the scientific process, has been inappropriately absent in science education.[29] Arguing the validity of claims can help students understand the process of science, how to make and analyze an argument that is made, understand content better, and keep engaged in the learning process.

Furthermore, comments allow educators to identify misconceptions since it has been shown that identifying and addressing misconceptions increases learning gains by students.[30] For example, in the same SciShow video there is a comment that states: "The idea that observing a particle changes how it acts and gives it a definite state doesn't seem right to me, because that is a very biocentric view of how the world works, because if you think about it, what defines an observer? Does it need to have an eye, does it need to be able to measure something? For all we know a particle can have s [sic] definite state if it's just near another particle? That particle can be considered an observer right? If not tell me why because I'm pretty sure there is no law in the universe that defines what an observer needs to have to be an observer." This is an example of a misconception that is possibly due to the use of the word "observer." In a reply, another user responded: "When we say observation we only mean that it directly interacts with another thing, i.e. any particle or force that causes a change, or transition from a probable state to a definite state. A measurement of a photo [sic] entering a small chamber is one such example, but the photon's wave function would behave exactly the same whether any human or other being was watching." This type of exchange is an illustration of how learning on YouTube can be an active process.

Edutainment

Edutainment is the combination of education and entertainment. There has been criticism of this idea, for example, by one author who stated "when education and entertainment are brought together under the same roof, education will be the loser."[31] The author goes on to say that, "There certainly is a tension between education and entertainment, but it is one that can be resolved by creating an atmosphere which is serious and enjoyable."[31] Care must be taken when justifying a single mode of education based on the educational successes of a few, since it is quite possible that those individuals who were not successful previously may have benefited from alternate modes of education such as edutainment. Furthermore, while much work has been done in the cognitive domain, we should not forget the significant influence the affective domain has on learning.[32] In that regard, the addition of entertainment may aid in learners having a positive affect towards a particular academic subject or learning in general. In addition, edutainment can serve to inspire students, especially those who are underrepresented in science such as women and minorities, from considering a degree and/or a career in the sciences.

Edutainment should not by any means replace more traditional forms of education but rather should serve as supplementary so that those who have difficulties with understanding content have another venue to seek clarifying information. Of course edutainment needs to be analyzed critically for its effectiveness as an educational mode; however, it should not be dismissed purely for unsubstantiated reasons. Though more research is necessary in this area, there have been indications that entertainment can be a part of education. For example, humor has been encouraged to be used to teach physics[33] and geology.[34] As more researchers critically analyze the effectiveness of education on YouTube, they will likely produce insights on what aspects are working and what needs to be improved.

Nature of Science

Lastly, YouTube might propagate incorrect notions on the nature of science. When a viewer learns an interesting fact about nature, he/she might think that science is solely a body of facts that is dictated by a small group of people. At the end of watching a video, this could be at best the viewer taking away a fun fact to discuss with their family and friends, but at worst with a wrong idea of how science works. If a viewer thinks that science is solely a body of facts then they will not be prepared when scientific understanding of natural phenomena evolve nor will they be able to grapple with questions that currently have no empirically-based answers. In addition, care must be taken to convey that science is a process that anyone can participate in. Videos should encourage viewers to ask more questions, to seek information on their own, to make certain observations of nature themselves, and to perhaps conduct a few exploratory experiments.

Recommendations

At the time of the study, it was noted that the American Heart Association (AHA), the Red Cross, and the European Resuscitation Council (ERC) did not have videos on YouTube teaching the techniques of Cardiopulmonary resuscitation (CPR) while videos of incorrect techniques were being viewed by the public.[35] This is similar to the AAS not having its own presence on YouTube to inform the public of accurate scientific knowledge and of new research in the field of astronomy. However, it should be noted that work has shown that videos produced by reputable organizations at times do not get a lot of engagement (i.e. number of views, viewers making comments, and voting that they like the video).[36] However, the AAS need not compete for popularity but rather should provide high-quality content for eager learners and interested educators much like is being done by the ACS.

There are many best practices that can be learned from those who have already produced science videos on YouTube. Videos need to be short, recognizant of cognitive load and they should be produced from a journalistic perspective of putting the most important message early.[27] If experts are interviewed, they need to be vetted to make sure they are speaking with the idea of comprehensibility in mind. The audience may get lost when words or concepts are used that they are not familiar with. It would be pragmatic to reference the many high-quality science videos already on YouTube for definitions and basic explanations.

Making science videos on YouTube can be difficult due to the diversity of the audience.[27] Therefore, if the resources are available, it would be best to have different channels for different purposes. A weekly channel might cover interesting research that was published during the week and a monthly channel could be akin to Annual Reviews and summarizes research in a broader sense.

Finally, it would be prudent to not only produce high-quality, up to date, and accurate videos but to also conduct education research to judge the effectiveness of this effort. Did viewers learn the ideas being presented? What are common misconceptions and did videos effectively address them? Did viewers' attitudes about science change as a result of watching the videos? Were some viewers encouraged to pursue a degree and/or a career in science? These are a small number of interesting questions that could be addressed with a future study based on online science videos.

Conclusion

People use YouTube to gain knowledge that is factual, procedural, and/or conceptual. The popularity of science videos on the platform demonstrates that there is a demand for high-quality, up to date, and accurate videos. While there are many science channels on YouTube, a few are backed by reputable organizations such as the AAS. Producing science videos for YouTube would be beneficial for the membership of AAS in helping them connect with new audiences. This connection would be great as a global science outreach effort. Therefore, it is important for the AAS to establish a presence on YouTube so that eager seekers of formal and informal astronomy education have trustworthy content on the platform. While it is essential for the AAS to establish a presence on YouTube, it is also key to conduct education research on the effectiveness of the videos that are posted so that improvements can be made in the future and the potential usefulness of this type of effort can be empirically established.

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Framework to Guide the AAS Education Task Force's Decision-Making Regarding Educational Programs for the AAS

White paper for AAS Education Task Force 2016

April 29, 2016
Prepared by: Dr. Edward Prather

This white paper is intended to inform the efforts of the AAS education program/efforts for the next several years. The focus is on programs that will help improve the attitudes, and beliefs as well as increase the capabilities of, the AAS membership to engage in meaningful and proven education activities.

I believe the activities we propose must be aligned with the goal of:

- "Elevating the knowledge, skills, and abilities of the AAS members to better be able to educate all the audiences they engage with".

Rather than provide an exhaustive list of the programs I think we should create or participate in, I will provide more information on the framework I think the AAS should use to guide its decision-making regarding educational programs for the society. AAS members are continuously engaged in educational settings with the next generation of AAS members, and they need to be aware of, and well trained at, implementing proven instructional methods shown through research to increase the knowledge and abilities of their learners. AAS members also educate students engaged in STEM careers that support and are closely associated with astronomy/astrophysics. Additionally, AAS members engage in courses serving a very large population of non-science students. These non-science students represent our <u>nation's teachers</u>, business leaders, journalists, artists, authors, politicians, as well as <u>tax payers, voters, and parents</u>. This is an incredibly important population of learners that the members of the AAS have access to (in large numbers), and as such must receive special attention with regard to the education programs of the AAS. And finally, AAS members engage in informal education settings where tremendous impacts can be achieved by the efforts of our members. I strongly suggest that the AAS invest in a series of targeted educational programs that bring state of the art educational practices to its membership using training and mentoring that is informed by best practices in professional development. The greatest impact on the understanding of what we do in astronomy, and the ability to participate in and support what we do, will come through the efforts of our members as they engage with all these different populations of learners and the public – and if our members are well trained and equipped with the best materials available today, it is possible that the educational programs of the AAS could finally fulfill the Society's mission statement at a level that we could all be proud of.

I know from working in the trenches with AAS leadership and Council Members that appropriate levels of funding and institutional support for these programs will be difficult to secure. **I believe that the best strategy for the society will be to invest in the**

training of its members rather than investing in particular educational experiences that target audiences outside the AAS membership. When the discussion of working with teachers or creating public engagement programs are brought to the AAS leadership and Council, an unproductive debate always ensues; however; I would be deeply saddened and terribly disappointed if the AAS leadership and Council were unable to create serious investments in the training and support of its membership to better be able to educate the audiences I have identified.

Lastly, I strongly suggest that the task force examine what has been done and has been shown to be successful by our peer professional societies with regard to their educational programs – while this viewpoint should not restrict our creativity there are critical lessons to be learned from and exemplar programs we should certainly be aware of and informed by.

Respectfully,

Dr. Edward E. Prather

Associate Professor
University of Arizona
Department of Astronomy

Executive Director
Center for Astronomy Education (CAE)

520-405-0974
eprather@as.arizona.edu

AAS Education Task Force : White Paper

Getting Educators Involved In Authentic Astronomy Research

L. M. Rebull, 4/27/16

1. Introduction

Astronomers are in a unique position among the sciences in that every little kid loves dinosaurs and space (e.g., Fraknoi 1996, Trumper 2006), and many adults *still* love space. Astronomy is a doorway to many fields, among them physics, chemistry, geology, biology, computer science, math, engineering, and even art. Teachers open that door.

Any long-term education plan, including the AAS Education Task Force, should take into consideration that reaching K-12 teachers provides powerful leverage – if you change the way a teacher thinks about science, about scientists, about astronomy and astronomers, then through them, **you reach every student that teacher comes in contact with through the rest of their careers.** That population of students is different (broader!) than the population reached by our colleagues teaching Astro 101 in colleges. Few high schools would hire a football coach who had never played the game. The reality is that very few high school science teachers have *ever* worked with *real data*, much less done authentic science of any sort.

> *"I always thought just from programs on TV and in the classroom that astronomy was more or less completely figured out. Learning that it isn't is pretty exciting." – NITARP student*

The best way to get students and the rest of the public inspired is to bring science into the places where they are so that we can help inspire them. By getting active astronomy researchers working with K-12 teachers, it provides real-world applications of classroom concepts. This has been proven to engage students (e.g., Strimel 2014). By having scientists work with teachers, one can provide someone for students (and their families!) to look up to. This humanizes and de-mystifies science.

Moreover, the Next Generation Science Standards (NGSS; http://www.nextgenscience.org/get-to-know) calls for teachers to incorporate authentic scientific inquiry (as opposed to cookbook labs). Many teachers, however, have not had authentic inquiry experiences during their training. As the transition to the NGSS is made, additional professional development opportunities will be needed to provide teachers opportunities to do authentic science.

> *"One evening [during our Caltech visit], while working on some homework, I had the realization that THIS WAS REAL. There is no [known] answer, in fact, no one knows the answer. I can't just go and ask someone the answer. It was like a light bulb went off and I experienced a feeling of excitement and also felt a little bit scared. I thought to myself – Is this how astronomers feel about their work? It was a great feeling and exciting that I too am part of this now." – NITARP educator*

2. NITARP

One way we have been reaching teachers is NITARP, the NASA/IPAC Teacher Archive Research Program.

(http://nitarp.ipac.caltech.edu). In our program, educators get an *authentic research experience* using *real data and tools*. A group of educators is paired with a mentor astronomer, they write a proposal (which is peer reviewed), they do the research (including a research trip to Caltech to work in person with their mentor for a week), they write up the results, and they take it to an AAS meeting and present their work in the science poster sessions. We model the **research process from start to finish**, something that is lacking in most teacher programs. Most of our participants have been and are high school (HS) teachers, but some are middle school, and a few have been community college or other informal educators such as museum staff.

"I've been involved in many professional development activities and [NITARP] is by far the best one I've ever done." – NITARP educator

There are several characteristics of NITARP that make us different than most of the programs out there. Our program is aimed at educators for the multiplicative effect as described above. We select participants from a nation-wide application process. Our program involves educators for at least 13 months (Jan - Jan). Research indicates that it takes teachers engaged in professional development 30-100 hours over a time period lasting 6-12 months to have a lasting impact on instructional practices (Darling-Hammond & Richardson 2009); adopting new technology for their classroom can take sustained effort over three to five years (Brinkerhoff 2006). NITARP has just such a sustained interaction with our educators; we work intensively for a year, but alumni can be involved over longer times if they choose. Our participants do real astronomy research. We don't know what we will find when we start out, which surprises many. Being involved in the whole process can revolutionize teachers' perceptions of "the scientific method" as it is commonly taught (e.g., Weinburgh 2003). Our participants present their results in the same sessions as professional astronomers, and they must 'hold their own' in that domain. They are not sequestered in a separate session where people know *a priori* that they are HS teachers and students; they're in the same session as others doing that kind of astronomy. Our participants are also encouraged to involve students in the entire process.

3. Teachers Using Data and Doing Research

In a carefully controlled experiment on HS teachers in New York state, Silverstein et al. (2009) found that, for teachers who participated in doing real scientific research, there was a measureable impact on their students:

> *"In years three and four after program entry, participating teachers' students passed Regents science exams at a rate that was 10.1% higher than that of nonparticipating teachers' students."*

Note that the students showing these improvements did not participate in the research with the teacher (as would be the case in NITARP); simply having the teacher participate in research was enough to make a difference in how the teacher approached their classroom.

Partnerships between scientists and educators (such as NITARP) benefit everyone involved. Teachers gain content knowledge and understanding of the nature of science, curricular resources, and increased professional development opportunities. Students' learning of science is enriched and their exposure to role models and scientific careers is enhanced. Scientists gain communication and instructional skills, exposure to teaching careers, and interest in future outreach activities. (See, e.g., Raphael, Tobias, & Greenberg 1999; American Institute of Research and Wisconsin Center for Education Research 2005; Siegel et al. 2005; Abbot & Swanson 2006, Sadler et al. 2010.)

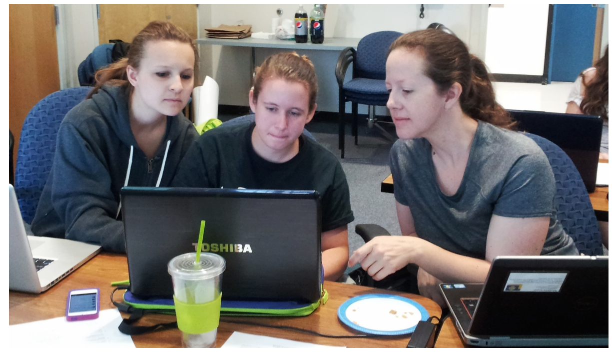
Authentic research is by its very nature consistent with the NGSS (as described above), but also myriad national and state teaching standards, including Common Core (http://www.corestandards.org/). Inquiry-based labs using real data are also compliant with these standards (e.g., Llewellyn 2012), and are more "portable" from classroom to classroom than authentic research. Working with real data is a very different experience than reading about scientific discoveries. Both labs (with real data) and real research give students more authentic "real world" experiences, making them better prepared for college and a career. Doing hands-on scientific research in HS has been shown to make it significantly more likely that the student goes on to a career in science (e.g., Roberts & Wassersug 2009; Sadler et al. 2010).

There are many programs that provide laboratory-style exercises using real data, covering a full spectrum of time commitment, necessary expertise, computing resources, and wavelengths. I maintain a list of all the programs I know of that get real astronomy data into the hands of (pre-college) students and teachers on the NITARP site here: http://nitarp.ipac.caltech.edu/page/other_epo_programs
Some are active and ongoing, and some are no longer being funded; some have static lesson plans and/or activities available on their site for anyone to use. The list includes programs from all over the world, but the list is heavily dominated by US-based programs, meaning that **AAS members likely have a hand in most of them**.

> *"NITARP is without a doubt one of the two most valuable pieces of professional development work I have done in 25 years of teaching, and by far the most rewarding content-related work. I think that what you are doing is really unusual and valuable." – NITARP educator*

Doing actual scientific research in the classroom (or out of it) is the deepest experience with real data on a full spectrum of programs; research is admittedly for the most dedicated participants drawn in by the other, simpler programs. There is demand for teacher research programs like these; our NITARP oversubscription ratio has hovered around 4 for the last five years. Teachers want to do real science, but there are not many opportunities. Some are intimidated by the very thought of doing real science, but having teams in NITARP (with the structure that comes with it) helps give them support throughout the effort.

I co-authored a paper that surveyed all the projects that we could find that had ever gotten real astronomy research into HS classrooms. In Fitzgerald et al. (2014), we summarized the characteristics and lessons learned from 22 different projects running at any time since the early 1990s. There have been many successes in these programs, but we identified both funding and evaluation as consistent weak points.



From the perspective of NITARP, we have had difficulty in raising funds for operations, and for evaluation. Our program is seen as too science-focused for many education funding opportunities, and too education-focused for many science funding opportunities. Because of the very nature of the NITARP experience, we provide an intense experience to few people per year, so our "footprint", on the face of it, does not look very large. In contrast, though, because of the richness of the experience, we often are able to make deep changes in our participants' views of science in general and astronomy in particular. We also require that our educators spend time sharing their experience with their school, district, community, etc., which broadens our impact. We were able to find some limited funding for a detailed evaluation of the NITARP 2013 class. (This is currently available in Rebull et al. 2015 as a poster; we are working on writing it up for publication.) The findings include the conclusion that NITARP is an invaluable authentic research experience that clarifies for educators the true nature of scientific research. Since 2005, we've worked with 98 educators from 37 states, presented 53 science posters and 58 education posters, written 8 research journal articles and 2 education journal articles. **Our educators reach ~21,000 students *per year*.**

4. The Future, and Possible AAS Roles

The US Federal 5-year STEM Education Strategic Plan says on page 9 that a goal is to:

> *Increase and sustain youth and public engagement in STEM. Support a 50 percent increase in the number of U.S. youth who have an effective, authentic STEM experience each year prior to completing high school.*

This is a document that helps guide the spending of federal dollars on STEM education. **Partnerships like NITARP are one very powerful way to meet this goal.**

There are many possible avenues for continuing and expanding NITARP and other programs like it, which I now discuss. The AAS could have a role in many of them.

Our model works, and could be expanded to more teams and even more subjects. The limiting factor will probably always be money, but good astronomer (or other science) mentors must be found (and trained) as well.

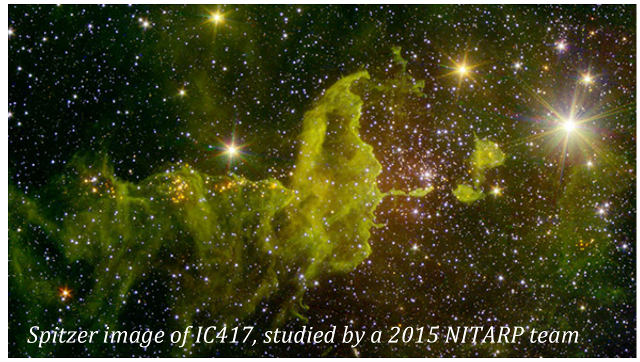
To reach a broader base of educators, we need a training infrastructure to bring people along with the basic astronomy, math, and computer science skills needed to do research. I can envision an interlinked network of AAS/NASA/NSF programs feeding that identified need in the teacher community, with the programs working with each other as a coherent educator training stream. They would teach the skills, including the basics of astrophysics (or other sciences) to prepare educators (of any sort) to do research. To make the incredibly diverse community efforts of NASA, NSF, and AAS (both AAS-sponsored and simply AAS members working on their own) work together and really be interlinked would be challenging, and **could be something that the AAS helps provide** – even just knowing who is doing what and the diversity of opportunities could be helpful. A secondary (and desirable!) effect of this would be to identify gaps in the array of training opportunities. This kind of effort was implemented within NASA EPO several years ago, and seems to have been quite successful in identifying gaps in resources and filling them. This inventory should also include the non-federally-funded programs getting teachers and students in contact with real data, such as those programs associated with the PBS show NOVA, and citizen science efforts such as the Zooniverse.

My envisioned infrastructure, in addition to working across agencies, should also include educational training and support for getting best practices and more astronomy data into the classroom. We have a steady stream of applicants to NITARP who already have PhDs; by coming to NITARP, they evidently believe they will learn better how to integrate data into their classrooms. NITARP's goal is to share how science really works, and someone with a PhD should already know how science works. Increasingly, recent astronomy PhDs find themselves in HS classrooms as "alternate" careers, and some of them are coming to us for help**.** This steady stream of NITARP applicants suggests that **there is a need for training** not just in Astro101 large class teaching techniques, but in getting data and inquiry-based methods into the smaller classroom – in all three settings, HS, community college, and 4-year college.

Some educator participants in my envisioned infrastructure would deliberately work towards an ultimate goal of doing actual astronomy research. However, not everyone wants to do research. For many others, just getting activities using real data into the classroom would be a significant improvement over the status quo. NASA already provides a clearinghouse for some activities (NASA Wavelength), and the AAS has historically focused mostly on Astro 101 needs. I see a **need for a collection of inquiry-based labs using real astronomical data**, spanning the audiences of HS, 2-year college, and 4-year college instructors.

Additionally, there are many potential avenues for education research concurrent with this effort. Better, ongoing evaluation (within a given year and longitudinal) is critical to shaping a larger, more complex program. Funding is necessary for making evaluation work, and finding good evaluators is difficult. The AAS could provide a **network of evaluators** who have worked with astronomers before and would be willing to take on the evaluation of these (and other) programs. That way, it would become easier for AAS members to find good (and willing!) evaluators.

With about 100 alumni now who have gone through NITARP (or its immediate predecessor), we work to support this community, giving them connections to resources and opportunities; I also make video tutorials to provide asynchronous "continuing education" for our alumni. I would like to improve this effort, create a formal Community of Practice[1], where there are regular opportunities for interaction, including a broader community of alumni (grade 8-12) educators who have gone through other programs besides NITARP. Ideally, this should include funding opportunities to attend conferences to present research (science research as well as education research).



Spitzer image of IC417, studied by a 2015 NITARP team

We have identified the need for a **journal dedicated to student and teacher research** that includes a review process (with PhDs as the reviewers). There are some student-based journals that have appeared in the past, but most are no longer functioning, or do not have any astronomy, or are only for science-fair-style (single student author) projects. Few real research papers in ApJ/AJ are single author; there should be room for a class or an after-school club to co-author a refereed paper led by their teacher (or student leader).

The NITARP alumni community now tells me that their biggest hurdle is coming up with good project ideas that work for them and their students to keep going after their intensive year with NITARP; I would like to find a way to **link astronomers** who have appropriately-scaled ideas **with these skilled teachers**. Enabling new collaborations between these teachers and the astronomy community and within our alumni community (teacher-to-teacher) is hard, because the partners necessarily must have good rapport, which is hard to predict or control. Periodic in-person conferences (associated with an AAS?) where interested astronomers and NITARP alumni gather for resource sharing, idea sharing, etc., may be critical to fostering new connections. As always, though, money is the limitation for such in-person meetings.

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[1] A "Community of Practice" is a group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wegener, McDermott, & Snyder, 2002, p. 4).

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Thank you to astronomer Dr. Varoujan Gorjian (and NITARP collaborator, and AAS member) for his comments and suggestions.

THE NEED TO DEVELOP EVIDENCE-BASED TEACHING PRACTICES IN AAS MEMBERS

Travis A. Rector (University of Alaska Anchorage)

Most AAS members have been, or will be, instructors of a class. However, very few have received any formal training on how to be an effective teacher. Without such training most instructors simply mimic the teaching they received- primarily lecture-based classes that do not employ "best practice" teaching methods. Best-practice methods are defined as those that have been rigorously studied and have been shown to lead to significant gains in learning over traditional teaching methods. This also includes methods that are shown to improve engagement and learning in underrepresented groups in astronomy. Examples of such methods are peer learning, in-class lecture tutorials, and authentic scientific research experiences.

The AAS should help its members to be better teachers by introducing them to such teaching practices and, in some cases, training them on how to use them. This is especially important for new faculty who face tremendous pressure to prepare new classes from scratch, often with little help from their department. It is especially important to reach these new faculty at the start of their teaching careers, as there is tremendous disincentive to invest the time and effort to redesign established courses.

While few AAS members have been "taught how to teach," most are well versed in scientific research methods. The AAS should also encourage its members to apply their research skills to the classroom. That is, to use assessment tools (e.g., concept inventory tests) to critically assess student gains and use this feedback to improve their teaching. These assessment tools can also provide evidence of success in the classroom, which can be helpful for purposes of promotion and tenure.

Going Above & Beyond: A Cross-Disciplinary Planetarium Program

Morgan Rehnberg*† and Rebecca Nevin‡

May 13, 2016

Abstract

We introduce and discuss the format, efficacy, and future plans for a planetarium show series developed at Fiske Planetarium that aims to find intersections between areas of current scientific inquiry and pressing societal issues. The public's interest in astronomy is used as a gateway to exploring a broad range of topics in a non-traditional environment. Professional development for the graduate-student speakers and meaningful participation from the audience are key focuses.

Introduction

Planetaria have traditionally served as relatively single-purpose facilities for astronomy education. The increasing installation of digital projection systems, however, enables a dramatically-richer range of programming to be offered. In response to the installation of a fully-digital system at the University of Colorado's Fiske Planetarium, we undertook the development of a new flagship live presentation series, *Above & Beyond: Cosmic Conversations*. The series strives to accomplish four main goals:

- Explore compelling intersections between scientific inquiry and societal issues.
- Introduce the public to a broad cross-section of the young scientific community.
- Provide graduate students with the experience of developing a professional-quality presentation.
- Place the audience on the same level as the scientist by enabling a bidirectional conversation.

Since September 2014, we have produced 14 episodes of *Above & Beyond* covering a wide variety of topics and presented by a diverse set of graduate-student speakers. In the following, we share how we've worked to accomplish the above goals in our first four seasons and how we're looking to improve in season five.

Exploring our goals

Multi-disciplinary education

The overriding goal of *Above & Beyond* is to transform the planetarium into a place of broader learning. The key component to accomplishing this is our requirement that each talk be a narrative that tells either the story of how science has informed a larger societal experience or how society has directed and shaped the science we do. For example, in "Can We Go There?" we explored how current difficulties in space travel manifest in popular science-fiction films. Broad public interest in astronomy and space exploration also makes it the ideal gateway through which we can examine contentious issues. The question of what astronauts eat in space provided a non-threatening framework in which to explore millenia of food modification in the show "Give Us This Day Our GMO Bread."

*Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder
†morgan.rehnberg@colorado.edu
‡Center for Astrophysics and Space Astronomy, University of Colorado at Boulder

A diversity of speakers

A persistent problem in science education and public outreach is a lack of diversity in the scientific figures visible to the public. This has been shown to dramatically alter who people perceive can be a scientist[1]. In addition to the same underrepresentation issues experienced by astronomy as a whole, public figures in science tend to be substantially older than those they are trying to educate. Restricting this series to graduate-student speakers ensures that visitors meet a scientist at a career level different than most others with which they may be familiar. We hoped that requiring the content and style of the presentations to be different than a typical science talk (for the public or not) would encourage a more diverse collection of participating speakers and we are pleased to report promising results. Seven of our nine speakers thus far (drawn from the astronomy and geology departments) have been women and we've had participation by members of a number of underrepresented communities including people of color, those with disabilities, LGBT scientists, and the religiously-affiliated. We choose shows based on submitted pitches, so this diversity represents scientists who have independently chosen to participate.

Critical professional development

It is increasingly important for scientists to be able to communicate their work effectively to multiple audiences. The CU graduate astronomy curriculum does not provide any explicit opportunities for gaining these skills, so *Above & Beyond* has been a valuable opportunity. Involving graduate students in a large, team-oriented production helps them learn to incorporate feedback from a variety of sources and craft a message that meets several diverging requirements. Creating an episode is a month-long process and many presenters remark that they feel a new confidence in how to present information in a way that is mindful of their intended audience.

Leveling the field

Public outreach too often relies on the authority of the speaker to convey a message and excludes the experiences and voices of the other participants in the learning process: the learners. With *Above & Beyond* we have strived to empower the audience for our shows. One key tactic for this has been to require that speakers present on topics unrelated to their personal research. This forces them to be learners in the same way that their audience will be. The other measure we take to promote this is to end each talk not with Q&A but instead with a question for the audience. For example, after "Ne'er a Drop to Drink," a talk about water scarcity, we challenged audience members to take and defend positions about how best to reduce water consumption in the United States. We observe that, like a classroom discussion, the presenter must actively facilitate the conversation or it will devolve into a more traditional question-and-answer format.

Looking to the future

As we look towards the future, we hope to simultaneously maintain the societal connection and discussion aspects of *Above & Beyond* while developing the series to focus on depictions of science and scientists in popular culture. By pivoting the focus of the talk series, we hope to engage the public's interest in science and technology as it is depicted in the media by directly addressing some of their favorite movies, TV shows, books, video games, and more. The mainstream media engages in scientific topics from cloning and intergalactic war to global warming and zombie apocalypses; this provides a unique opportunity to address and educate the public on topics on which they may already have some familiarity and enthusiasm. In this manner, we will first engage, then educate, and finally spark discussion on science ethics or science technology.

Likewise, by discussing the depiction of scientists, engineers, and mathematicians in the media, we

[1]See, for example, "Stereotypical Images of the Scientist: The Draw-A-Scientist Test." `http://onlinelibrary.wiley.com/doi/10.1002/sce.3730670213/epdf`

hope to open conversational avenues on diversity in STEM. We will then connect the reality of the state of diversity in these fields to the (often disappointing) depictions of scientists in popular media. Something we've struggled with in the past with *Above & Beyond* is incorporating conversations about diversity into each talk. In this new series we hope to more consciously focus on issues of diversity in each talk and conduct a thoughtful and well-planned ending discussion. However, it is still important to maintain a diversity of speakers. To achieve this goal, we will avoid narrowing the subject matter down to a level that discourages participation. Instead, we plan to work with the speakers to develop a talk that delivers a narrative as well as a conversation on elements of diversity in the sciences. Additionally, we hope to widen the discussion of diversity to include non-physical elements of diversity such as the diversity of scientific methodologies and identities.

Summary

We believe that the planetarium is an ideal environment for engaging a broad audience on a wide variety of topics. The public's interest in astronomy provides an ideal entry point for discussions across the spectrum of science and technology. Such far-reaching interactions come with the responsibility to ensure we properly represent the nature of participation in STEM today and to encourage a more inclusive idea of what science can be. This includes not only those engaged in the scientific undertaking today and those who may join the enterprise in the future, but also every citizen whose views impact the directions we go and whose lives are enriched by the discoveries made.

AAS Education Task Force White Paper
Alexander L. Rudolph
California State Polytechnic University

(Lack of) Diversity in Graduate Education in Astronomy

According to the latest statistics from the NSF (2015), underrepresented minority (URM) students (shamefully) made up only 3% of PhDs in Astronomy from 2002-2012, while making up 30% of the general population. **There were a total of *4±2* URM PhDs per year in Astronomy during that period *nationally!***

The 2010 Decadal Survey of Astronomy highlighted this problem, noting that, “Little progress has been made in increasing the number of minorities in Astronomy,” and recommending “Partnerships of community colleges and minority-serving institutions [MSIs] with research universities and with national centers and laboratories” to overcome this underrepresentation.

Recently, there have been programs, such as the Fisk-Vanderbilt Master’s-to-PhD program (fisk-vanderbilt-bridge.org), Columbia Bridge-to-the-PhD program (facultydiversity.columbia.edu/bridge-phd-program-natural-sciences), the National Astronomy Consortium (science.nrao.edu/opportunities/student-programs/nac), CAMPARE (www.cpp.edu/campare), and Cal-Bridge (www.cpp.edu/calbridge), which have begun to address the problem of improved access for URM, female, and other underrepresented groups (LGBT, disabled, etc.) to Astronomy PhDs.

However, to truly address this lack of diversity requires examining the graduate education system in Astronomy at a fundamental level. Many of the programs mentioned above draw on education and other social science research showing that traditional measures of ability used in graduate admissions, particularly the GRE, are not good predictors of degree completion or long-term success in research, the two main goals of most PhD programs, but *do* strongly suppress diversity in the applicant pool. The AAS Council recently acknowledged these facts in a statement suggesting that Astronomy PhD programs eliminate or make optional the GRE exam in graduate admissions (aas.org/governance/council-resolutions#GRE).

Eliminating the GRE would be a great (but not easy) first step, but by itself would not solve the problem. Graduate programs need to examine their entire programs to consider how, through admissions, their financial aid decisions, their qualifying exam, and their overall mentoring and support structures (or lack thereof) for graduate students, particularly those from underrepresented groups, they enhance or suppress diversity in their program and in the field overall. Astronomy graduate programs need to collaborate with the education and social science researchers who have studied these problems. Astronomers have a lot to learn from them about how we select and support (or don’t support) our graduate students, if we are willing to learn.

There was a AAS report on graduate education that David Helfand mentions in his White Paper (aas.org/archives/BAAS/v29n5/edrpt.html), which contains exactly one fleeting reference to diversity. It is time for our community to make diversity in our graduate programs a priority, by putting resources behind the effort.

Some suggestions might include:

- Special sessions or plenaries at AAS meetings on the topics of diversity, equal access, the role of the GRE in admissions, and the social science research on what predicts success in PhD programs and long-term professional success. While there have been such sessions, they have generally been parallel sessions attended by a small handful of people active on these issues—we need to find a way to engage the larger community on these issues
- One or more dedicated national (and/or a series of regional) meetings devoted to these topics, sponsored by the AAS. Participation of department or admissions committee chairs would be crucial to the success of such a meeting, but is also a big challenge
- Workshops on mentoring (both academic and research) for faculty in graduate programs, both held at AAS meetings and encouraged/facilitated/supported at home institutions or regionally, focusing on the special mentoring needs of underrepresented groups
- Continuing to put the weight of the society behind such efforts as eliminating the GRE from admissions, and the overall examination of the structure of PhD programs, through public statements like the GRE statement
- Strong advocacy with funders (NSF, NASA, etc.) for support for equal access/diversity programs like the ones mentioned above (and others to still be created). While the Astronomy division has been good about supporting such programs, they are under constant pressure to cut them when budgets are tight, and continued strong statements from leadership like the AAS are critical to protecting and expanding such support
- Support for continuation of the good work on general inclusion in the field started at the Nashville meeting
- I welcome other suggestions

The AAS, as the major professional society for Astronomy, is the right vehicle to drive such a fundamental re-examination of graduate education in our field. In addition, the AAS should work closely with other organizations (e.g., American Physical Society, Astronomical Society of the Pacific) that are also working to address these and similar issues, to advance an even broader examination of diversity and inclusion in the wider context of STEM as a whole, and to leverage this wider examination to leverage national resources (NSF, NASA, DOE, etc.) to support these efforts.

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Transitioning Undergraduates to Research Careers: Introducing the Astrophysical Literature in Bites

AAS Education Task Force White Paper

Nathan Sanders[1], Susanna Kohler[1,2], Ashley Villar[1,3], Chris Faesi[1,3],
and the Astrobites collaboration

[1]Astrobites collaboration
[2]American Astronomical Society
[3]Harvard-Smithsonian Center for Astrophysics

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A barrier to entry for new researchers

Scientific literature simultaneously serves two roles: it is the primary means by which we communicate our results to our colleagues, and it provides a historical record of progress in our field. But the literature should also play a critical third role—the introduction to our profession for the next generation of astronomers.

Unfortunately, success in the first two roles often prevents success in the third. Effective communication between peers relies on shorthand. Experts automatically unspool references to familiar concepts into multitudes of context and fluidly interpret discipline-specific jargon and units. To establish a legacy continuous across generations of scientists, the literature must make constant reference to decades of research results, presenting an impenetrable web of dense manuscripts to newcomers. This common vocabulary of ideas—thoughts, terms, and historical findings—is integral to concise communication among specialists, but obscures meaning to students of the field.

Many students' first contact with the literature presents a barrier rather than a facilitator to a career in research. The process starts when an undergraduate approaches a professor or other researcher, asking to take part in a research project for the first time. For a mentor eager to get a first-time researcher up to speed, it can seem convenient and straightforward to provide the student with a set of the canonical, comprehensive written works in the field. But without prior exposure to the literature, the first paper sets a rather high activation energy for students to surpass to become an active contributor to the field.

Undergraduate research experiences have been shown to be an integral step in the STEM career path (see e.g. Seymour et al. 2004, Sadler et al. 2009), and we believe that lowering this activation energy could be an important step towards making the practice of scientific research more accessible to—and retaining students from—backgrounds traditionally underrepresented in the sciences (see e.g. Ceci et al. 2009, Hernandez et al. 2013), improving science self-efficacy (Robnett, Chemers, and Zurbriggen 2015) among emerging researchers, and generally improving research productivity by early-career scientists, the broad base of academic research staff.

The graduate student writing collaborative Astrobites seeks to lower the barrier to entry to the astrophysical literature for undergraduate students. In this white paper, we begin by describing Astrobites' publishing model and its pedagogical philosophy. We then advocate for specific actions to galvanize the AAS community around making progress towards our key goal of lowering the barrier to undergraduate participation in research. In particular, we recommend the creation of a committee of educators, undergraduate students, and Astrobites members to pursue five key questions regarding the use of Astrobites in formal educational settings.

The Astrobites model

Astrobites is a unique reader's digest for the astrophysical literature, written by graduate students for undergraduates. Our volunteer collaboration of nearly 80 graduate students and recent graduates, from 45 institutions around the world, has contributed about 1500 pieces since our founding in 2010. Each article on our site is typically read by an audience of about a thousand people within a day of publication. Under our innovative authorship model, 26 graduate students on our "regular rotation" each write one article per month summarizing a recent journal paper of their choosing in a brief format accessible to undergraduates. They then receive editorial feedback from two other members of our collaboration. This year, the AAS formally announced its support for Astrobites while affirming its disposition as an independent graduate student organization.

Astrobites' pedagogical model is designed to address several discrete challenges that face scientists at the undergraduate level.

Access: At major research institutions, undergraduates may be provided with opportunities, and even structurally incentivized through assistantship programs, to participate in research. The curriculum at such schools often includes substantive term research projects, capstone courses, independent study course credits, and paid research assistantships. But such opportunities are less prevalent at primarily undergraduate, teaching-focused, or otherwise less research-oriented institutions. And while excellent inter-institutional programs such as the NSF Research Experience for Undergraduates offer a critical service to students with limited access to research experience at their host institution, they are only able to serve a limited and highly self-selected portion of the community of young scientists. DeHaan (2005) identified increasing access to experiences as a prerequisite to undergraduate research 'revolutionizing' education.

Scaffolding: Even for well-motivated students at well-equipped research institutions, identifying the right entry point into research can be challenging. While some academic mentors or resources have high expectations for prior knowledge of research methods, favoring students later in their undergraduate careers, others have slower-moving, more heavily-pedagogical approaches, favoring earlier-career students.

Specialization: Very few institutions are large enough to have faculty research spanning the full range of disciplines within astronomy. As a result, undergraduates' awareness of and exposure to current astrophysical research topics is often severely limited by the faculty resources available at their institute. As with the problem of access, this challenge becomes more pronounced at smaller institutions or those without a large astronomy program.

Time: The undergraduate years can be one of the most time-limited and stressful phases of a scientist's career, even absent any commitments to research. When a student's introduction to a field of study is a pile of manuscripts, even a small amount of progress understanding the field can require an enormous time investment on the part of the student. For many students, this is implausible—in much the same way as it would be impractical for many busy junior faculty members to take up a new foreign language.

The Astrobites pedagogical model helps to substantively address each of these issues for our thousands of readers.

Access: Astrobites is a freely accessible online resource, enabling all students to benefit from the research paper summaries we publish. Moreover, any reader can ask practicing scientists questions about the articles through our comments section, and can learn about the professional path into research through our career navigation articles. While reading can never be a substitute for experiential learning, Astrobites supplies a portal into the world of research and the "culture of science" (Hurtado et al. 2008) that helps to put students from diverse academic backgrounds onto the same footing.

Scaffolding and specialization: Astrobites' library of articles—covering nearly 1200 past research papers—provides a variety of perspectives on almost every topic of current scientific interest in astronomy. This collection can support students with varying backgrounds and levels of preparation.

Time: Astrobites' posting frequency is strictly limited to one article per day, such that a student reading Astrobites can receive a broad survey of new research throughout the field with a daily time investment of only about 10 minutes.

Opportunities to impact the undergraduate classroom

We have argued that the founding goal of Astrobites—to facilitate the transition of undergraduate students to research practice—addresses a highly impactful issue in astronomy education. As demonstrated by AAS's support of Astrobites, the Society shares this goal. We further argued that Astrobites has implemented practices that specifically address the key impediments to progress on that issue. Here we call for the AAS and its members to take action to further this shared priority.

As an organizational goal, we are seeking to study and promote the use of Astrobites in the undergraduate classroom as a formal educational tool. In our May 2016 reader survey, 40% of undergraduate respondents indicated that they have had instructors using Astrobites in the classroom, while 20% of senior researcher respondents had used Astrobites in their role as a course instructor. Encountering statistics like this in our sixth year of operation suggests to us that there is a persistent and sizable community of active users of Astrobites in the formal education setting, as well as substantial opportunity to expand that community and extend the impact of the site. We would like to better understand and optimize the effectiveness of Astrobites as a resource in that setting.

We previously presented a list of strategies for incorporating Astrobites specifically in undergraduate classrooms in Sanders et al. (2012). In particular, we proposed 1) assigning Astrobites articles as regular reading assignments, 2) using Astrobites articles to guide students in writing their own topical literature reviews, 3) having students develop in-class presentations using Astrobites as a key reference, and 4) interacting with the Astrobites community and graduate student authors by using our comment feature as a discussion forum.

Here we advocate for the AAS community to form a committee of faculty and other undergraduate educators, undergraduate students, and Astrobites collaboration members that would develop new mechanisms for incorporating Astrobites in the classroom as well as track and study the usage of these and our previously proposed mechanisms of incorporating Astrobites in the classroom.

We would suggest that the committee focus on the following five questions:

1. **Promoting uptake:** How can awareness of Astrobites as a resource for formal education be increased? How can the incidence of Astrobites being incorporated into undergraduate course curricula be raised? What resources can be identified for promoting uptake of Astrobites in the classroom and supporting educators in their use of this resource?
2. **New mechanisms for implementation:** Beyond the four strategies outlined in Sanders et al. (2012), how else can educators incorporate Astrobites in their course designs? What mechanisms would maximize student engagement and the pedagogical impact of Astrobites?
3. **Measuring impact on understanding:** How can we rigorously test the impact of Astrobites on improving and/or hastening undergraduates' familiarization with the astrophysical literature, and their development into productive research contributors? What methodological approaches should be taken and what opportunities exist to do this experimentation?
4. **Measuring impact on perceptions:** What impact does Astrobites readership have on the perception of research and current career plans of undergraduates? What level and duration of readership is required to generate substantive impacts?

5. **Expansion to new settings:** Aside from the undergraduate classroom, what other formal educational settings could leverage Astrobites? How could Research Experiences for Undergraduates (REU) or other undergraduate research programs make systematic use of the site?

As the first step in the formation of this committee, we propose that the AAS put out a call for potential committee members, educators and students, to gauge interest and collect feedback on the principles discussed in this paper and the committee goals. We believe that the combination of 3-5 highly motivated educators, 2-3 undergraduate students, and 2-3 Astrobites members would constitute an effective committee.

We thank the Astrobites Education Task Force for the opportunity to provide this perspective.

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Public Outreach and Educator Professional Development at Towson University: Baltimore Project ASTRO
http://baltimoreprojectastro.org/

A Response to AAS Education Task Force Call for White Papers on Education, Professional Development, and Public Outreach Conducted By and for its Members

Jennifer Scott (jescott@towson.edu) and Rommel Miranda (rmiranda@towson.edu),
Baltimore Project ASTRO Co-Directors
Karen Schaefer (kschaefer@towson.edu), Baltimore Project ASTRO Coordinator

Founded in 2008, **Baltimore Project ASTRO** has served students and educators in Baltimore and the surrounding region. We are a partnership between **Towson University**, the **Maryland Science Center**, and the **Space Telescope Science Institute**, and we are a site of the nationwide Project ASTRO program which was begun by the Astronomical Society of the Pacific in 1994.

As a Project ASTRO site institution, Towson University is responsible for recruiting educator and astronomer partners and for bringing them together for an annual professional development workshop. At the workshop, partners are provided with materials from the Astronomical Society of the Pacific (ASP), and they learn how to forge effective collaborations, how to make use of local astronomy resources, and how to implement hands-on, inquiry-based astronomy activities in their classrooms. The material supplied by the ASP consists of a DVD including 133 field-tested hands-on activities, from programs and projects around the US, 17 topical guides to the best sources of information in print and on the web, 52 background articles on astronomy and education, 10 recommended sequences of activities to help students learn some of the topics most often found in the K-12 curriculum.

The **goals** of Baltimore Project ASTRO are to:

1. Promote active learning methods in science classrooms that engage both teachers and students and improve student attitudes towards science.
2. Offer role models for students by showing them working examples of who scientists are and what they do.
3. Provide professional development for teachers through workshops, in-service training, and one-to-one partnerships with local content experts.
4. Conduct concrete assessment of the program to disseminate to the Project ASTRO National Network and to improve our methods in the future.

Baltimore Project ASTRO serves our unique region with its high concentration of space science professionals and amateur astronomy groups. We have created and fostered nearly 50 active partnerships between Maryland educators and professional or dedicated amateur astronomers associated with many different organizations. Since inception, we have had broader impacts on over 5,000 K-12 students across our state by providing authentic science learning experiences. Our partnering elementary, middle and high school educators have come from 5 local area school districts, and our astronomer partners have represented the following institutions: American Meteor Society, Carnegie Institution of Washington, Department of Terrestrial Magnetism, George Mason University, Harford Astronomical Society, Howard Astronomical League, Johns Hopkins Applied Physics Laboratory, Lowell Observatory, Loyola University, Maryland Science Center, NASA's Goddard Space Flight Center, Robinson Nature Center, Science Magazine, Space Telescope Science Institute, Towson University, University of Maryland, Baltimore County, University of Maryland, College Park, U.S. Naval Observatory, Westminster Astronomical Society.

We have published two empirical research studies on our efforts in *Astronomy Education Review*, and are working on two additional studies that are currently in preparation. We have also published a manuscript in the ASP publication *Mercury*. We have shared our research findings at 6 peer-reviewed science education conferences such as the *Association for Science Teacher Education (ASTE),* the *National Association for Research in Science Teaching (NARST),* and the Mid-Atlantic Association for Science Teacher Education (MA-ASTE). We have made one poster presentation at the *American Astronomical Society*. Our full publication list is included below.

We are supported by a grant from the National Science Foundation (AST-0952923). Past support has been provided by the NASA Maryland Space Grant Consortium and by the Towson University Fisher College of Science and Mathematics.

We now face specific challenges in sustaining our efforts in program growth, and assessment and dissemination when supporting funds become exhausted. For our program to remain viable, it is essential for us to have adequate funding to support a part-time program coordinator (10-15 hours/week), professional development workshop materials and venue, program assessment, and travel support to share our findings in the astronomy community.

Baltimore Project ASTRO Publications

Science Education Research Journal Publications

1. Miranda, R.J. (2012). Urban middle-school science teachers' beliefs about the influence of their Astronomer-Educator Partnerships on students' astronomy learner characteristics. *Astronomy Education Review, 11(1),* 1-9.
2. Miranda, R.J. (2010). Urban middle school teachers' beliefs about science learner characteristics: Implications for astronomy curriculum. *Astronomy Education Review*, *9(1),* 1-9.

Astronomy Education Magazine Publications

1. Miranda, R.J., & Van der Veen, W. (2014). **Project ASTRO: Evolving to remain relevant.** *Mercury, 43(2),* 33-39.

Science Education Conference Presentations

1. Miranda, R.J. (2015). Characteristics of Effective Astronomy Education and Public Outreach Programs. *Proceeding of the Association for Science Teacher Education Mid-Atlantic Regional Conference, Lore City, Ohio.*
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OpenStars: Web-based Pedagogical Computational Modeling for Astronomy Education and Public Outreach

A response to the AAS Education Task Force: Call for White Papers

C. Ian Short, Ph.D., PPhys
Professor, Department of Astronomy & Physics, Saint Mary's University
Halifax, NS, Canada

9 May 2016

The goal of the OpenStars project (www.ap.smu.ca/~ishort/OpenStars/) is to adapt scientific computational modeling and visualization of stars and stellar observables so that it is readily accessible as a web application on any commonplace personal or classroom computing device for teaching and learning purposes. The motivating idea is that modeling the visible layers of a star and visualizing a star as seen with various basic instruments is not only useful for research, but also for providing an interactive science exhibit and a pedagogical apparatus for classroom demonstration and for curiosity-driven investigation. Both personal computing devices, and web-application programming and visualization languages, are now powerful enough that approximately physically correct, rapidly responsive, platform-independent modeling can be deployed publicly, and provided with a didactic, pedagogical user interface that is engaging and informative.

The recent OpenStars applications GrayStar and GrayStarServer are examples of this approach applied to general stellar atmospheric and spectrum modeling and the modeling and visualization of related observables. Physics-based modeling quantities, computed rapidly (a few seconds run-time) in any web-browser, are used to display renderings of direct, intuitively meaningful observables, and, optionally, more technically advanced plots for instruction beyond the first-year University level, all in the browser. These applications may be used as the basis for demonstration-based interactive pedagogy of the type found to be effective by the physics education research (PER) community. This is especially important in the critical undergraduate unit on stellar atmospheres and spectra where astronomy students make their first contact with ideas that are crucial for interpreting radiation emerging from any kind of object.

Instructors may download their own local installations of the OpenStars applications, or run them over the web, and share their experiences and ideas on the social media forums linked on the OpenStars web site. It would be useful if the community were willing to develop and field test classroom activities and labs based on these applications, measure their efficacy, and share the results.

Applications like those of the Open Stars project have a broader significance. They may be used to exploit the popular allure of web-application programing, browser-based graphics, and open source code development to entice young people into our discipline. They serve as a proof of concept for the level of scientific computing that may now be implemented on low-performance commonplace clients in platform-independent web-deployment languages, and how the computed results may be used to create credible physics-based renderings that are meaningful to the public. The OpenStars applications should prompt modeling experts in other areas of astronomy and astrophysics to “webify” and didacticize their modeling for EPO purposes as well.

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Contact:
Christine Shupla, Education Lead
shupla@lpi.usra.edu
281-486-2125

Educator Professional Development in Astronomy

A white paper for the American Astronomical Society, submitted by the Education and Public Engagement Department of Lunar and Planetary Institute.

There is an ongoing need for providing quality astronomy professional development for classroom teachers, informal educators, and other out-of-school time programmers. The American Astronomical Society's policies and programs can play a critical role.

The Role of Astronomy in Education

Astronomy, planetary exploration, and related space sciences play an intrinsic role in science education.

- Astronomy remains an engaging topic for all ages, capable of capturing and retaining interest. It is an educational "hook" that can be used by teachers, camp leaders, museum and planetarium programmers, and other out-of-school time programmers.
- Students are taught fundamental science processes such as making observations, analyzing patterns, and forming and testing predictions using consistent predictable astronomical phenomena, such as seasons and lunar phases.
- Astronomy tightly correlates to the nature and history of science, given its practice among cultures around the world from ancient times, its connections to development of modern science, its utility in demonstrating how science is conducted, and the opportunities it presents to clearly distinguish real science from other philosophies and beliefs.

The Need for Professional Development

In general, teachers are more in need of professional development for Earth and space science content than any other science[1]. (Other informal science educators face the same challenges).

- Of all of the science subjects, Earth (and space) science teachers are least likely to have a major in their subject [2,3].
- On state standardized tests, students often perform lowest on the Earth and space science standards; for example, in the 2013 Texas science assessments, 8th grade students on average performed poorest on Earth and space science standards compared to all subjects [4].
- A significant amount of research has demonstrated the issues students and their teachers face in spatially complex astronomy topics such as seasons and lunar phases [5,6,7].

Conducting Quality Educator Professional Development

Research has shown that professional development should be ongoing and long-term[8,9], involve subject matter experts[10], enable teachers to develop strategies for eliciting prior knowledge and use formative and summative assessment information[9], and involve active learning, including planning classroom implementation[11,12,13]. Astronomers and planetary scientists provide a critical role as subject matter experts as providers fine-tune the content to be delivered in professional development.

It is impossible to achieve all of these in short one-time sessions. Quality professional development requires that participants receive ongoing updates, opportunities for further professional development, or at least contacts for follow-up questions. Content (including age-appropriate activities, resources, and assessments) should be available in a format that participants can return to after the workshop has ended. For example, see the Lunar and Planetary Institute's website on the Sustainable Trainer Engagement Program (http://www.lpi.usra.edu/education/step).

The Role of AAS in Astronomy Education

The members of the AAS play an important role in astronomy education, long before students attend college. Their research generates the excitement and enthusiasm that astronomy enjoys. Their stories about their lives, career pathways, and how they do their research brings this science to life, as a demonstration of who conducts science, and why and how we do it.

The American Astronomical Society can play a critical role as an advocate for educator professional development in astronomy education, as an advocate for scientist participation, and in encouraging and enabling astronomy education professional development, both external to and in connection with AAS and affiliate conferences.

Submitted by the Lunar and Planetary Institute

Contact:
Christine Shupla, Education Lead
shupla@lpi.usra.edu
281-486-2125

The LPI Education and Public Engagement team collaborates with its partners to make current Earth and planetary science content available to all audiences. LPI professional development programs include teacher trainings, Explore professional development workshops for librarians, camp programmers, and other out-of-school time facilitators, and workshops for planetarians and science museum programmers. http://www.lpi.usra.edu/education

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Relevance of Astrostatistics and Astroinformatics to Education

Aneta Siemiginowska for the AAS Working Group on Astroinformatics and Astrostatistics

Astrostatistics is the science of drawing well-grounded inferences from astronomical data. It forms the foundation for robust algorithms and principled methods that are applied to a variety of problems in Astronomy. Astroinformatics involves code, data and machine learning. Both are now emerging as fields of research that are being rigorously pursued at the intersection of observational astronomy, statistics, and data science.

It is well understood that major advances in Astronomy and Astrophysics are driven by improvements in instrumentation. But not as well understood is that at each stage new challenges arise in analysis that must be solved before correct inferences can be drawn. Scientists have to be aware of appropriate analysis techniques and methods that exist and should be employed to deliver the best inferences. Such awareness can only be achieved with adequate training in the area of Astrostatistics and Astroinformatics. The current curriculum does not take training in this field seriously. The courses are not offered or not required for the astronomy students. Furthermore, scientists are often required to write code or specifications for software while their training in software is very weak. For example in a recent document, Software User in Astronomy: An Informal Survey Momcheva & Tollerud (2015) report that all astronomers in the survey use software, 90% write software, but only 8% received substantial training.

WGAA organized a Session on *Astroinformatics and Astrostatistics in Astronomical Research: Steps Towards Better Curricula* at the 225th AAS meeting in Seattle. This session was very well attended by students, post-docs and faculty, with the standing room only. The two Astrostatistics Sessions at the 227th AAS meeting last January were even more popular indicating growing awareness of the field in the AAS community and the need for such a training.
The main result of the Seattle Session was a list of issues that are relevant to AAS Educational Task Force:

- Training faculty is important. Courses for faculty during the teaching breaks could help. There are courses available online that should be advertised with an advice on which course is worth taking.
- Funding the courses for faculty is needed. Logistics of such training and organization is needed.
- The community should encourage the Data Science training of the students and faculty.
- The concern was raised about advisors who may not support training in data science. It is understandable that the students may have difficulties in learning if they do not find the support in their immediate advisors. The community needs to be aware of such situations.
- The changes to the curriculum are often impossible, or take a long time to implement. Often an addition of a new course means a deletion of another course. Such modifications need to be carefully considered and require a strong motivation. An advice on how it is done in other places could help. There is some room when considering the curriculum change in the required vs optional courses. Optional course if listed can accrete students if it is well designed, interesting and advertised.
- Astronomy is not alone - all fields have similar problems. We should work with like-minded faculty in other fields and with the top-level administrators to make these changes university-wide.
- Brain drain is happening and is unavoidable. Keeping talented scientists in academia is and will be even more challenging. In the era of the Big Data the astronomy community have to be able to compete with the industry and recognize that the Data Science is an important part of the modern astronomy research.

Appreciation for Astrostatistics and Astroinformatics has increased substantially over the past decade: the number of published works has increased dramatically, astronomy graduate curricula are slowly adapting to teach more advanced statistical techniques, and professional interest groups are being formed in both Astronomy (AAS Working Group on Astroinformatics and Astrostatistics in 2012) and Statistics (ASA Astrostatistics Interest Group in 2014) societies. IAU established a new B3 Division on Astroinformatics and Astrostatistics last year highlighting the importance of the field.

AAS Educational Task Force should endorse educational efforts that improve knowledge of future astronomers and prepare them for the era of data driven astronomy brought with new advanced instruments coming online in the next years. Some of the general issues can already be addressed:

- There are now several modern textbooks in Astrostatistics that can be taught in graduate courses: Gregory (2005), Wall & Jenkins (2012), Feigelson & Babu (2012), Ivezic/Connelly/etal (2014), Andreon & Weaver (2015). However, a textbook in Astroinformatics is still needed.

- Specialized informal training in Astrostatisitcs and Astroinformatics is quite active. About 10% of the world's astronomers (mostly in the younger generation) have received ~1 week training in Astrostatistics & R over the past decade. Informatics training has had less coverage, but software tutorials and Hack Days are growing. From the ASAIP Meetings listing for 2015, there have been 17 events worldwide that were educational in nature:
.Astronomy 7, COIN Residence Program #2, Kepler Exoplanet Populations Hack Week, School of Statistics for Astrophysics 2014: Clustering and classification, Astro Hack week 2015, The iPTF Summer School, Third La Serena School for Data Science: Applied Tools for Astronomy, Summer School in Statistical Data Analysis and Data Mining in Astronomy, ZTF Summer Undergraduate Astronomy Institute, SciCoder 6 Workshop, Summer School in Statistics for Astronomers XI, Python in Astronomy, Big Data Week, Tools for Astronomical Big Data, Brazilian School of Regression Models, Astroinformatics School, Thematic program on statistical inference learning and models for Big Data.

- A vast amount of general informal training in statistics and informatics is available on the Web. Here are results for three searches of YouTube: *Bayesian computation (1500 videos), Nonlinear regression (6400 videos) Computational astrophysics (1200 videos).*

- Formal Web-based training (e.g. Coursera, statistics.com, OLI, MIT, JHU) is also available but oriented towards other fields.

- The resources directly applicable to education have been compiled by Oceans of Data including a Reading List and Profile of a Big-Data-Enabled Specialist.

On the other hand, the formalized training and the permanent place of the field in the curriculum is still missing. We encourage the AAS Educational Task Force to direct the community and to set the high priority on education in the area of Astrostatistics and Astroinformatics.

Members of the Steering Committee of the AAS Working Group on Astroinformatics and Astrostatistics:
Aneta Siemiginowska (Chair, CfA), Kirk Borne (Booz Allen Hamilton), Tamas Budavari (JHU), George Djorgovski (CalTech), Eric Feigelson (Penn State), Eric Ford (Penn State), Alyssa Goodman (Harvard University), Joseph Hilbe (IAA), Zeljko Ivezic (University of Washington), Ashish Mahabal (CalTech), Alex Szalay (JHU), Rick White (STSci), Padma Yanamandra-Fisher (SSI).

Ways Scientists Can Meaningfully Participate in Education and Outreach,

Denise Smith: White Paper Thoughts (via email text)

I'm writing to you on behalf of the Office of Public Outreach here at Space Telescope Science Institute, and on behalf of the multi-institutional team behind our newly awarded NASA's Universe of Learning education cooperative agreement.

The close coupling of science expertise with education and communications expertise is central to the work that we do here in the Office of Public Outreach to make astronomy exciting, engaging, understandable, and relevant to an increasingly diverse audience. The direct connection with the science is also a central tenet of our Universe of Learning education program.

As we develop the Universe of Learning program and continue our STScI outreach/communications activities, we would like to work with the AAS Education Committee and AAS membership to raise awareness of the ways scientists can meaningfully participate in education and outreach, both through our own resources and programs, as well as those offered by the broader education and public outreach community.

We also feel it is important to continue communicating the importance of directly involving scientists in education and communicating astronomy to the public, and the value of using astronomy to illustrate key principles of science and technology – and the practice of science itself – in both formal and informal education environments.

Teaching with a Planetarium

Alex Storrs
Physics, Astronomy, & Geosciences
Towson Univ.
June 2016

Planetaria by their nature lend themselves to “sage on the stage” presentations, with the audience passive in their seats. The involved educator must go out of their way to engage the students with active learning. Here are some things that I have found to be successful.

Engage before turning off the lights. Asking for questions before the show (e.g. “Has anyone not been in a planetarium before?” then select someone who doesn’t raise their hand and ask them to describe what they are about to see, for the benefit of the folks who did raise their hands) can be effective, but must be used carefully. I have found that students in grade 3-5 have so many questions that you might never get to the show—leave time for q&a after the show, and tell them you are going to do this…

Engage during the show. Since we never do “canned” shows, I ask them to speak up during the show, saying loudly “I have a question” and then waiting until I can stop and address it. I usually do this with a joke about the title “Professor”, meaning “one who professes” or talks incessantly, and it may take me a little while to come to a halt.

Allow for excitement. I try to make the show exciting, and tell the students this before the show. Tell them it is o.k. to clap and cheer but that they should stop making noise quickly, as the show can’t go on until they do. This is a good thing for their teachers to hear as well, as these folks frequently expect their students to remain absolutely quiet throughout the presentation. I believe is an unrealistic expectation, especially for elementary school groups.

Teach lessons besides astronomy. Sure, you can do the rise and set of the Sun and the stars, what is out tonight, the zodiac and the polar constellations and how to find the North Star, but you can also teach lessons about social justice. Talk about the “drinking gourd”, not just the Big Dipper, and if you know them describe what other societies call the same asterisms. One of my favorites is to tell the story of Cassiopeia and Andromeda, queen and princess of Ethiopia, and Cetus and Perseus (“You can tell he’s a hero because he has a pointy head”) and then ask “So if they’re from Ethiopia, what color is their skin?” This introduces the concept of dark skinned people up in the night sky, which can be a bit of an eye-opener to children immersed in our white-dominated society. I point out that most of the human race has dark colored skin. You can use the planetarium to teach social justice!

I don’t usually display the pictorial representations of the constellations, although this too can generate excitement. Instead I point out some of the more obvious asterisms and encourage the students to make their own pictures, **exercising their artistic talent**.

After introducing the **Milky Way**, I point out that our modern understanding is only a hundred years old, so it is not surprising that we still think it is something special. I then point out that in our modern understanding, every star we can see is part of the Milky Way—the ones that are close to us, we see as individual stars, while the light from the ones farther away blends together into a smooth wash. Once you realize this, the grandeur and majesty of the thing can pop into place, given the planetarium's projection.

Our planetarium uses the Starry Night projection system, which has a "Go There" feature. This allows us to view the sky from places off of the Earth. If we fly out to the Moon, we can see how its phase is controlled by what fraction of the side we can see is lit up by the Sun, and has nothing to do with the Earth's shadow. If we **land on the Moon**, we can have a horizon panorama made from the Apollo 17 landing site, showing the rounded mountains and deep craters, and can talk about the rain of dust particles that rounded off the original sharply peaked mountains over billions of years, teaching a lesson in deep time.

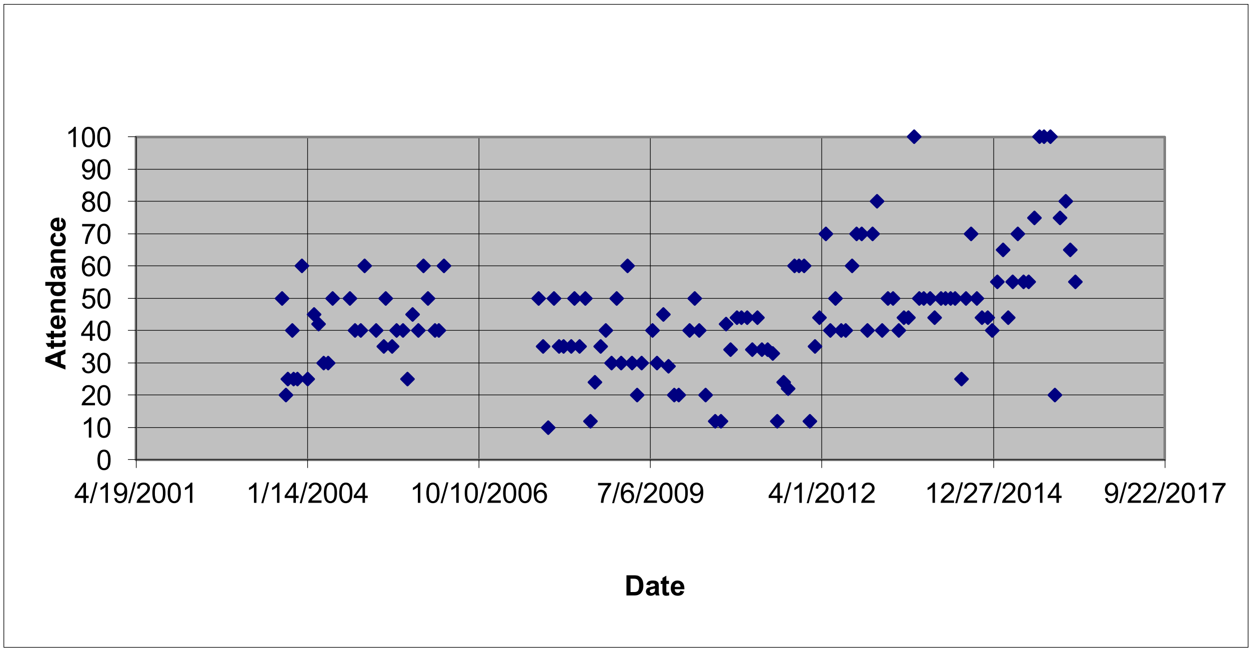
Flying out to Saturn is always fun, as the rings are well displayed. Letting "planetarium time" pass at 300x the actual rate allows us to see the system from a variety of angles, and shows the shadow of the planet on the rings as well as the shadow of the rings on the planet.

Flying out to Pluto allows for a discussion of what makes a planet. With a more advanced class you can delve into planetary formation, how orbital resonance appears to have played a large part and that Pluto can be thought of as a planet that didn't get its act together—it was still forming when the planet formation process stopped. A vast oversimplification, but I think it helps ordinary people understand why Pluto is different.

Someone is going to ask about **Black Holes**, so if you have a simulation of a symbiotic system like Cyg X-1 and can fly out to that, you can talk about the limits of physics. It may interest your audience to know that science doesn't know everything, and that we can put limits on what we don't understand. Both notions are contrary to popular belief.

Remember that planetaria can be used with the **lights on**, and you can incite class discussion before, during, and after the presentation. Pairing and sharing ideas can be a little challenging if the students are isolated in large reclining seats, but if they are in regular seats or (ideally) on benches they can easily turn to the students on either side, or in front or behind, to actively engage with some of the ideas you have presented.

We also have a portable planetarium and I believe Prof. Miranda is providing a white paper about that. The portable planetarium averages 29 shows per year although this is a minimum—each "show" usually includes several classes. Over a thousand people per year visit our portable planetarium and with an average of 77 shows per year in the permanent planetarium we reach over 4000 people in the same conservative estimate. We have regular monthly planetarium shows and the following plot shows the attendance over the years:



Note that since the refurbishment in 2009 the planetarium has 44 seats—the majority of our shows, even those held outside the school year, are standing room only.

The Scientist-Educator Partnership

AAS Education Task Force Whitepaper, May 2016

Frank Summers and Bonnie Eisenhamer[1]
Space Telescope Science Institute

Over the past fifteen years, we have worked together on the Hubble and JWST mission education programs. Throughout that time we have worked on, presented, and reviewed for others a diverse range of astronomy education products including classroom materials, web sites, K-12 student workshops, pre-service to master teacher professional development, and education / science / art exhibits. Our experience has taught us that there is one most critical element in creating high quality astronomy education materials: a true collaboration between an education-oriented scientist and a science-focused educator.

As a field, astronomy is more attuned to education than most science and technical subjects. In addition to teaching responsibilities as part of their positions, many AAS members help present the beauty and fascination of the universe through community colleges, public talks, blogs and social media, astronomy clubs, and museums / planetariums.

However, these experiences are not a substitute for the professional training of an experienced educator, especially for K-12 formal education. Astronomers simply are not trained to understand the minutiae of educational standards, the rigors of classroom preparation, the relentless pressure of parents, principals, school boards, and standardized tests, as well as the school, county, and state educational program politics. All of these factors and many other considerations have significantly affected the educational materials that we have worked on.

Of course, the converse proposition is also true. Educators cannot keep up with the myriad advances in scientific discovery to the level that they can present current information with accuracy and proper emphasis. The classification of Pluto is a terrific example that brought to the fore the idea that even fundamental knowledge is continuously being re-examined. These days, it is perhaps even more difficult for an educator to hone in on reliable sources when a tremendous amount of information and misinformation is available at the click of a mouse.

As a partnership, neither participant need know the full extent of each other's job. Nonetheless, to create a true collaboration, each must learn enough about the other's roles and concerns to the point that they can anticipate the reactions and guide their part of the work accordingly. Astronomers, for example, need to understand the developmentally

[1] Email: summers@stsci.edu / bonnie@stsci.edu

appropriate concepts for different audiences and the technique of scaffolding to develop an educational storyline. Educators, for their part, need to learn the translations of scientific jargon, an appreciation for proper vs incorrect analogies, and how to work with multiple experts who disagree. The accumulation of such collaborative knowledge takes quite some time and effort.

Many educational projects use consultants to fill in the gaps of their team's skill set. This is appropriate standard practice and we have served as both scientific and education consultants on numerous projects. The problem we encounter all too frequently is that the consultants are brought in too late in the process. It is quite disheartening to see a suite of materials presented as almost ready to go to print, and then find some ingrained scientific or educational flaws that cannot be removed without significant overhaul.

Our advice is always that the scientific and educational team should work together at all stages of development from brainstorming through draft versions to final review. We also recommend bringing the science team in for the educational evaluation so that they understand the usage, problems, and potential improvements from the field environment. For astronomy education projects, the use of consultants is necessary and fitting, but our caution is that, in practice, consultant interaction is under-utilized and can impact the quality.

We understand that we are lucky enough to have had astronomers and educators working together under one roof for many years. Both sides have grown immeasurably from the collaboration to the point where a dependence on the synergy is second nature. If the AAS is seeking to help foster and establish first rate astronomy education projects, we would encourage an emphasis on creating and developing scientist-educator partnerships throughout the community. AAS members should recognize that a commitment to a continuing peer relationship with an education professional, while creating short-term difficulties, will pay tremendous long-term dividends for both their work and the overall field.

From classroom lessons to online activities to museum presentations, we have seen numerous examples where the development efforts were unbalanced, and the results were not fully fleshed out to the maximum benefit of the audience. The scientist-educator partnership is a battle-tested approach that facilitates astronomy education products that include pertinent, appropriate, and up-to-date science along with the educational standards, auxiliary materials, and evaluation studies that promote effective and ongoing usage.

June 5, 2016

Gina Brissenden
Associate Director
Center for Astronomy Education (CAE)
Education & Outreach Coordinator

Dear Mrs. Brissenden:

I moved from a postdoc position at Caltech working under Prof. John Asher Johnson to the Ojai valley to take a position at the Thacher School in the fall of 2014. The main reason for this change of career path was to parlay the expertise I acquired while managing the MINERVA project into renovating and upgrading the Thacher School Observatory—the birth place of the Summer Science Program. The purpose is to initiate ongoing research programs to which students can contribute, and to develop a series of courses both specific to astronomy and general that will be integrated into the school's curriculum. Once mature, it is my goal to extend our new facility to the high school and undergraduate communities at large by offering educational and research opportunities.

The equipment for the project has been fully funded as of about a month ago (~$500k), and we are in the process of purchasing modern, research-grade equipment (primarily a new 0.7m optical telescope and high-quality imaging camera) that will be robotic and remotely controllable. I have been actively promoting this renovation (e.g. Hotwired IV, and AAS 227), and with my own expertise and through collaborations I expect to establish programs in several different fields including exoplanets, eclipsing binaries, and transient events such as supernovae followup, solar system objects, and variable stars. Our new equipment will be delivered before January 2017 immediately after which commissioning will begin.

The research programs that I am developing with the help of my professional colleagues (namely, Prof. N. McCrady of U Montana, Prof. J. Johnson of Harvard, and Prof. P. Muirhead at BU, among others) will facilitate mentorships across high school and undergraduate institutions to advance the understanding and practical use of scientific concepts, mathematical and statistical methods, and computer programming. I have found that students are deeply excited about "real" science—investigating questions or problems that do not yet have a well-defined answer—rather than canned lab exercises. So, I aim to provide an inviting backdrop of real science that will inspire students to build advanced quantitative skills and literacy.

After my first full academic year, I have already seen encouraging results. Doug Klink—a senior this past year, now accepted to Stanford and interested in computer science—presented an impressive poster at the 227th AAS meeting that highlighted his work simulating and recovering stellar parameters from eclipsing binary data. You may download his poster from this link. Also, Katie O'Neill—a sophomore last year—did a fantastic job on her poster at AAS227 explaining the site characterization and future plans of the Thacher Observatory.

While only a small fraction of our school's population will be interested and capable of contributing to research at Doug's or even Katie's level, there is much to be gained in having a legitimate research facility on campus. Upon my arrival to the Thacher School I began an astronomy club that garnered the support of a large fraction of our student body—30% of our 265 students—and there is much excitement about having a research facility on campus even from students who are very unlikely to do science research as a career.

I feel that connecting with these students is as important to building scientific and mathematical literacy as connecting with the highly quantitative students. To this end, we will be purchasing a high quality set of eyepieces on our new telescope (it has 2 instrument ports) that will facilitate frequent visits to our observatory from students and community members simply for the fun and excitement of exploring the cosmos.

I have already started teaching astronomy to Thacher students in elective classes over the past three terms. These include an astronomy survey course, a course that introduces the tools and concepts of research, and an advanced research class. However, the school has granted me two slots during the regular academic day next year for which I will be developing brand new courses over the summer that will be integrated into the science and mathematics curriculum. These courses will be a data science course and an astronomy fundamentals course.

Given the Thacher School's high demands for their faculty, I have been finding it difficult to carve out enough time to work on curriculum development as well as make progress on my research—primarily my work on eclipsing binaries with Prof. P. Muirhead at BU. My involvement with the professional community is an integral part of the program as this is what will connect students to the "real" science that they find so inspiring and motivating. Therefore, I am actively looking for ways to supplement my salary here such that resources can be shifted to cover part of my duties on campus required by full-time faculty, likely at the ~$20k per year level.

I know that you have roots in Ojai, and I welcome you to visit the school whenever you are in town. I would be happy to give you a tour of the facility and talk to you more about our plans and possible ways I can team up with the AAS to advance science and astronomy education with our new facility.

Sincerely,

Jonathan Swift

Director, Thacher Observatory
Math and Science Dept.
The Thacher School
5025 Thacher Rd.
Ojai, CA 93023
c. 510.292.7820

AAS Education Task Force White Paper – AAS Members' Engagement with the Public and Public Policy

By: Allison Towner, Ph.D. Candidate
Department of Astronomy, University of Virginia

Summary: this White Paper covers my personal recommendations for ways the AAS could improve its members' participation in EPO activities, especially engagement with public policy and elected officials. I strongly believe that EPO and science communication should be a more formal part of astronomy program curricula, since almost all astronomers are self-taught in this area. I believe that having some measure of formal training would significantly improve our effectiveness in this area and this, in turn, will benefit the Society. Below I discuss my reasons for the recommendations I make, and several concrete ways in which the AAS might begin to implement them.

One comment I often hear about astronomers' engagement with public policy is, essentially, a lament about the lack of it. Many astronomers are relatively good at engagement with the public, especially engagement about science content or new discoveries, and will manage to do one to a few EPO events a year. However, very few will also engage with their elected representatives. I know that this is an area in which the AAS is actively trying to improve. To that end, I would like to make a few recommendations based on my personal experience trying to engage more with public policy, and in trying to increase the interest of others as well.

As someone who has participated in the AAS Communicating with Washington program and in numerous EPO programs as an undergraduate and graduate student, I think it would be extremely beneficial to make astronomy EPO/communication training a more formal part of astronomy education, or at least professional development. I realize this recommendation is a significant change and quite a commitment in terms of time and effort on the part of both the Society and individual members. The reasons I think the AAS should consider more formal efforts are threefold:

1. *We don't really know how, because we are not taught:* I often find myself wanting to contribute to EPO and science communication efforts in general, especially where public policy is concerned. I am particularly interested in communicating the importance, process, and nature of science. However, I consistently find myself lacking the basic information, let alone scholarly background, that I feel would be necessary in order to do the job well. EPO and science communication best-practices in astronomy tend to be entirely self-taught or informally acquired. It is a skill expected of many astronomers, but formally taught to almost none.
2. *It would benefit the AAS:* I believe that the AAS has a significant stake in its members engaging well with the public and with policymakers. In essence this can be summed up as, "If you're going to do something, do it well." However, as mentioned in point (1), we as astronomers frequently learn our communications skills rather haphazardly.

Therefore, I believe it would significantly benefit the society to make sure that its members are prepared to engage with the public. We do not need to be experts, but having some formal training would hopefully make us a little more confident and effective in our EPO and policy-engagement efforts.

3. *Self-education is unlikely to happen spontaneously:* Finally, there is a practical consideration to all of this. Astronomers are all very busy people (as I'm sure all of you reading this are) and, in my experience, are unlikely to seek out the information I mentioned above on our own time, even if we are very interested in the topic. No matter our level of interest, teaching ourselves public communication skills or the intricacies of Congressional policy-approval and appropriations procedures is simply something that is not likely to happen on its own. Any effort the AAS can make to get more information to all of its members would likely help with the AAS's own efforts at engaging its members in public policy.

In consequence of the above, I have a few recommendations for concrete ways in which the AAS might make it a little easier for members to engage with EPO in general, and public policy in particular:

1. More formal efforts might include recommending making EPO training part of graduate curricula (as 1-credit seminars, for instance), and providing recommended course readings or supplemental materials for such courses.
2. The AAS might make personnel or funds available to hold colloquia covering these topics at interested institutions, covering especially (perhaps) its own Communicating With Washington program, or the background of the US Congressional budgetary and committee processes that it would be useful for CWW participants and others interested in public policy to know. It's pretty difficult to get every member of a department in the same room at the same time, but the one time it is likely to happen is during weekly colloquia. If the AAS wants to appeal to members more effectively than through email or sessions at the full meetings of the AAS, this might be a good method. Obviously this would be quite a large commitment on the part of the Society, and I list it only as a possibility, not a make-or-break activity.
3. The AAS could compile and host, or link, recommended materials for members interested in further self-education in these topics on the AAS website (behind the member login, if it would be better not to make the materials public). This way, members would still be somewhat self-educated, but at least would have a good place to start, and would also have some idea of what resources are considered most beneficial.

Obviously, the feasibility of any of these recommendations is best determined by you the Task Force, and by the AAS governing committee. Nonetheless, I wanted to suggest more concrete action and more formal training because I am concerned that we, as academics, too often rely on self-motivation for such activities when more directed efforts might be more effective – and because the current political climate suggests to me that such efforts are critically needed.

AAS Education Task Force White Paper – Undergraduate Recruitment and Retention

By:
Allison Towner, Ph.D. Candidate
Department of Astronomy, University of Virginia

Summary: This White Paper is a brief summary of the efforts in which I have been engaged to improve recruitment and retention to undergraduate astronomy/astrophysics majors. Based on my own experiences, I would like to emphasize to the Task Force the importance of peer-to-peer support, and departmental support that facilitates strong undergraduate cohorts capable of providing such support. I will also briefly discuss current efforts of my graduate department to build a mentorship program between our graduate and undergraduate students, with the goal of growing the undergraduate program. I have chosen this topic because, while many departments rightly focus on what they can do directly to improve their undergrads' experiences, it is also important to have a "critical mass" of dedicated undergraduates in the first place, and this can be difficult to achieve.

Undergraduate attrition is a layered problem, but one well-known component is a feeling of lack of belonging in one's chosen field, or the impression that one is struggling significantly more than one's peers[1]. Based on my own personal experiences, I believe that peer-to-peer support is an essential component in counteracting these potential pitfalls for undergraduate students. Obviously, this is a difficult problem to address because it depends on the voluntary, self-motivated participation of undergraduates themselves. However, there are several steps departments can take to actively encourage or facilitate the development of such strong cohorts.

In 2014, I help organize a session at the 223rd AAS meeting (Session 159, "Developing Our Own Future: Undergraduate Research and Enrichment Through Peer-Led Programs") which featured both oral and poster presentations by undergraduates from around the county about their own peer-to-peer research and support activities. Out of this session came several main themes. First, it is vitally important that undergraduates have their own space in a department – not just to do research, but to relax, hang out, eat, do homework, help each other with research, plan outreach activities, and generally just spend time together. This "down time" together helps facilitate a strong undergraduate cohort whose relationships are based not just on common courses but on common experiences outside of the classroom. It also helps build relationships between upperclassmen and underclassmen, often resulting in a lot of informal mentoring of the latter by the former. This strengthens the department overall and (in my admittedly anecdotal experience) helps reduce attrition among the underclassmen.

Second, the programs of each undergraduate group were unique to the needs of their particular population in their particular department. One was based research-grade telescope operation, another on physics labs and building electronics for fun, another on social needs more than academic needs, and so on. One might be tempted to conclude from this that there is no set formula for developing a strong undergraduate cohort. This is both true and untrue, I think. I would argue that this breadth of undergraduate activities indicates that the "formula" in this case is that whatever the department does must meet the particular needs of its undergraduate population at the time. This requires regular communication by the department with the undergraduates in the program, and deliberate action on the part of the department to address their needs.

[1] This is especially true for under-represented groups, but can apply to any student. See "Why So Few? Women in Science, Technology, Engineering, and Mathematics," especially Chapters 2, 3, 4, and 6.

There is also a third component to which I would particularly like to draw your attention. One prerequisite for this AAS Session was that these be undergraduate programs which were entirely run by undergraduates, and not a department-generated program[2]. From each group, there was a passion for what they were doing, a strong sense of ownership in their activities, and a pride in being able to contribute to their department and their peers in an effective, meaningful way. Therefore, I would like to emphasize that, whatever else a department does for its undergraduates (and they should be doing much more than I discuss in this White Paper – this merely covers my experiences with peer-to-peer support), it must be possible for their undergraduates to feel that they are valued by the department not just for their enrollment numbers but for their contributions to the department community. In particular, this is likely to contribute to the sense of belonging discussed above.

The preceding covers the summary of my experiences as an undergraduate. The following is a brief summary of the current activities of the University of Virginia Astronomy Department, which is currently in the process of building a mentoring program between its undergraduate and graduate students. In particular, we hope both to increase undergraduate retention and to bring the undergraduates more fully into the Astronomy. This program is run by interested graduate students, and has three main approaches: to hold regular information sessions on useful topics for undergrads (REU and grad apps, GRE prep, life in grad school, etc.), to hold semi-annual events for undergraduates ("Welcome to the Department" event just for them, departmental symposium showcasing undergraduate research, etc.), and to set up a once-monthly coffee-mentorship program, in which graduate student mentors get together with undergraduate mentees once a month over coffee and discuss current challenges, concerns, plans, etc. on which the undergraduate(s) would like advice. The strength of this mentoring program is that it pairs undergraduates with someone only one career stage ahead of them, meaning that the two might have more in common than an undergraduate and a tenured faculty member. This is *not* meant to replace faculty-undergrad advising, but to supplement it.

I hope that this description of undergraduate peer-to-peer and graduate-student mentoring activities has been helpful. It is by no means exhaustive and is (obviously) based on personal experience rather than scholarly articles. However, it is a topic that I feel is frequently overlooked in discussions of undergraduate retention (especially the topic of undergraduate peer-to-peer support). My intention in submitting this White Paper is that the Task Force keep these topics and activities in mind when making its recommendations to the AAS, especially if the Task Force will be making any recommendations about what departments can do to improve undergraduate experiences and retention.

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[2] We were interested in what undergraduates were capable of doing for themselves, which is admittedly rather different from the focus of this White Paper. However, I think many of the points raised in this session are directly applicable to the question of what departments can do to strengthen their undergraduate programs, because they can help facilitate undergraduate-led activities which will create a strong undergraduate cohort.

Dr. Catarina Ubach
National Radio Astronomy Observatory

The purpose of this white paper is to provide feedback to the AAS Education Task Force on the subject of public outreach. Including to provide information on existing activities and recommendation for future activities.

Public outreach

There are many forms of public outreach. I have mostly been involved with the interactive approach to outreach which involves physically going and talking to the public. Either as a speaker giving a public lecture, being a guide during a virtual astronomy tour, in a class room, at science expos, or at an open house for an observatory. These types of outreach activities are very rewarding since the feedback is initiate and generally positive and targets an audience that is already interested in astronomy. I have also been recently involved with forms of outreach that do not have a direct person-to-person interaction, just as being on a radio/video series and maintaining a scientific blog. Although these types of outreach activities do not have the person-to-person interaction that perhaps a more transitional public outreach activity as, these activities do have the potential of targeting a larger audience.

It is becoming the norm for the public to have a constant link to the internet, either through a smart phone or tablet. Thus there is the potential of reaching more members of the public community by taking advantage of the constant access to technology. That being said, there are many social media apps (Facebook, twitter, webpages, etc) already out there providing astronomy news to the general public. Unfortunately not all of these social media outlets are reliable or a referable source as we would define in science. Additionally, sometimes news articles get to the main stream media channels (CNN, LA times, local news networks) that appear to be true (or possible science) on the surface, but under closer inspection, are shown to be a hoax. These types of articles damage the integrity of the scientific community, and the public's trust on the scientific method. To mitigate this effect, I would suggest that AAS should continue to make an effort to provide scientific results from the Astronomical community to the media outlets directly or through the AAS webpage and advertise these news items through other media outlets. AAS should also put some effort in debunking (and/or correcting) hoax scientific news articles that appear in the major news outlets covering the topics of Astronomy. Another possible way that AAS can help the media cover scientific results is to provide a list of experts within each subject of astronomy that are willing to answer questions.

Another service that the AAS Education task force could provide is a database of the available recordings of public lectures and colloquiums. Many institutions have now started recording lectures and providing them on the institution webpage. It would be a good resource to have a database with these lectures, initially it could simply be a list of all the different institutions that provide this service with links to the lectures. The other benefit of a database provided by AAS, is if a teacher is trying to find information on a certain astronomy topic for their class, this can be a resource for them which would be more reliable than a random youtube video. This database could also be supplemented by the 3minute videos of PhD students explaining their thesis and/or an online public lecture series.

It is one of AAS missions to *"communicate and explain our understanding of the universe to the public"*, this task becomes more complex as the public exchange their one-to-one interactions for an online interaction with the world.

Concern about the Quality of Results of Education in Astronomy and the Effectiveness of Astronomical Educational Outreach

Education Task Force-White Paper- American Astronomical Society

Astronomical Expedition Team Leader!

Richard P. Wilds, BA MS AAS/DPS,HAD
Adjunct Instructor—Phone: (785)845-7304
Education—Special Education
Astronomy & Lab, World History,
Ancient History, East Asian Studies,
U.S. History, Readings in History,
Advanced Military and Science Studies.
Publications in Science and History

E-mail: astromaster@att.net
http://iota.jhuapl.edu/watts.htm

I have been teaching introductory astronomy classes and labs as an Adjunct Instructor for decades and have been leading astronomical expeditions that produced publishable results for over four decades. In all of these years I have maintained a consistent concern about the quality of results of education in astronomy and the effectiveness of astronomical educational outreach. A major problem with astronomical education is that it tends to be practiced while almost completely divorced from the real world of astronomy. Students are instructed from textbooks from which they are expected to reply the correct answer without actually knowing if it is truly the correct answer or why. So much of this could be corrected with proper classroom techniques where the teacher and student interact by providing supporting arguments to whatever answers are provided. When in the lab, the teacher should provide examples of the scientific method in which the class is shown a prediction, an observation is made, the observation is reduced in comparison to the prediction and the results published. Then the students are expected to make similar publishable observations in the topic of their choice. Unfortunately this is not what tends to happen in most introductory classes and this fact seems to be leading to an acceptance of scientific statements of fact in the real world whether they deserve such or not.

A timely example of this problem is occurring currently in front of us all. The United States will experience a Total Solar Eclipse on 21 August 2017. The entire scientific community has educated the general public of the complete misrepresentation that such an event MUST be observed from the Center Line of the Shadow cast across the continent or be faced with failure in the effort of observing this event. After months of effort and rejection from various sources I have finally been able to convince the editors of Sky & Telescope (August 2016) to publish my article suggesting the alternative of enjoying the similarly beautiful but also scientifically rewarding observation of obtaining a UTC video recording of the event at about one kilometer inside either the north or south edges of the Solar Eclipse Shadow. You not only experience a shorter period of the beautiful Totality, but you also will be able to experience about one minute of continuously changing Baily's Beads due to your specially chosen location in the path (at the Center Line Baily's Beads last no more than about one second). Students would be exposed to understanding the motion of the Sun and Moon, details in the structure of the Sun, topography of the polar regions of the Moon and experience in reducing the observations for publication.

This is only one example of the problem of assisting students in fending for themselves in their effort of understanding the universe. They need more real world problems for which they can produce publishable results that will allow them to know that they fully understand the concepts being discussed. Examples can be found in Solar System events such as occultations involving the Moon or also Mutual Events among the satellites of other planets (Jupiter being the most convenient option). Variable stars are another option that provides observations that would be easily verified. In today's new areas of astronomy, opportunities could also be found in computer simulations, searches for exoplanets or any number of other options, but these would need to be vetted carefully to be validated. The primary problem is to find a way to have students examine some of the fundamental experiences of the scientific method in action rather than in the simple regurgitation of memorized material on a test. In the end we might be able to have a few more students understand when other scientists make statements that should be questioned and we should be confident enough in our classroom activities to allow such questioning as an expected practice.

AAS Education white paper:
Outreach to the "Science Apprehensive Public"

Grace Wolf-Chase, Ph.D., Astronomer, The Adler Planetarium

The mission of the Adler Planetarium is to inspire exploration and understanding of the universe. In my own career, I have often found that the first step to fulfilling this mission is removing barriers that inhibit the full participation of human beings in the scientific enterprise. Exclusion is not limited to gender, race, and ethnicity, but to anyone affected by "chilly climate" issues and attitudes that encourage divisiveness, rather than inclusion. One of the biggest challenges to engaging many public audiences, including young people who might comprise the next generation of our STEM workforce, is that "culture wars" present science and religion as enemies, threaten the integrity of science education in our public schools, and claim that people must choose between a scientific worldview and their religious identities and communities.

To address this challenge, I have engaged in a substantial amount of outreach to religious communities for almost two decades. I have also participated in science and religion dialog at high academic levels. For example, I currently serve as the Vice President of the Center for Advanced Study in Religion and Science (CASIRAS[1]). CASIRAS is an organization of scientists and theologians that supports the Zygon Center for Religion and Science (ZCRS) in Chicago (where I am an affiliated faculty member) and co-publishes *Zygon: Journal of Religion and Science* in partnership with the Institute on Religion in an Age of Science (IRAS - not to be confused with the satellite!).[2] I served on the advisory board for *Teaching Religion and Science across the Seminary Curriculum*, a program that incorporates science and religion modules in *core* classes taken by seminary students at the Lutheran School of Theology at Chicago. I am also on the Steering Committee for the Albertus Magnus Society at the Siena Center, Dominican University, which explores issues at the intersection of religious belief or experience and scientific insight.[3]

I have brought my significant background and experiences to numerous programs bridging cultural differences and engaging the "science apprehensive public". I participated in the Perceptions Project[4] of the American Association for the Advancement of Science. I serve as a science consultant, and write astrobiology news articles, for The Clergy Letter Project[5], an initiative to demonstrate clergy support for science to the general public. I have taught classes, written articles (both

[1] www.casiras.org
[2] Harlow Shapley was the 2nd president of IRAS (www.iras.org).
[3] events.dom.edu/siena-center/albertus-magnus-society
[4] http://perceptionsproject.org/about/
[5] theclergyletterproject.org

popular and academic[6]), appeared in media interviews (including a "Short" on Oprah Winfrey's program *Super Soul Sunday*), and accepted many invited presentations that have resulted in a growing network of connections with religious leaders, both locally and nationwide. In June 2016, I will address high school youth at the Gustavus Academy for Faith, Science, and Ethics at Gustavus Adolphus College in St. Peter, Minnesota.

The number one goal of my outreach among communities of faith is to build trust and enhance mutual understanding across scientific and religious communities (which, contrary to popular messaging, overlap significantly). Public perception that science erodes faith and/or spirituality prevents many religious Americans, both young and old, from considering how science might empower them to affect positive changes in their communities and around the world. Ultimately, I envision creating a nationwide interdisciplinary professional network of scientists, religious leaders, and educators focused on helping faith communities build conscious and strategic bridges between their religious and scientific understandings of the natural world. This effort will require time, funding, and a huge dose of patience, but I feel it is absolutely essential that scientific and religious communities work together to address the many challenges that face us in the 21st century.

At the Adler Planetarium, my research has been integrated with public outreach through the citizen science initiative, the Milky Way Project (MWP). The principal goal of citizen science is to accomplish research that requires a large human effort. Launched in December 2010, the MWP was part of the Zooniverse (zooniverse.org) suite, which was developed primarily by interdisciplinary teams at the University of Oxford and the Adler Planetarium. To date, the MWP has resulted in several publications, including the discovery by MWP volunteers of an early stage in the development of massive star clusters[7]. A secondary goal of citizen science is equally important - to help the public better understand science and scientists by becoming our colleagues – participants, rather than onlookers. In the words of Goethe, "Wer Den Dichter will verstehen, muss in Dichter's Lande gehen," which translates as, "To understand the poet, you must walk into the poet's land." This articulates eloquently the basic philosophy behind citizen science and it also motivates the flip side – if we, as scientists, want to put a human face on science and gain public trust, we must meet others on their turf and at their level.

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[6] e.g., Wolf-Chase, G. 2012, *From Star Gazing to Astrobiology*, in The Routledge Companion to Religion and Science, ed. James W. Haag, Gregory R. Peterson, & Michael L. Spezio

[7] Kerton, C.R., Wolf-Chase, G., Arvidsson, K., Lintott, C.J., & Simpson, R.J. 2015, *The Milky Way Project: What are Yellowballs?*, ApJ, 799, 153

Don York White Paper (via Karen Masters)

A Comment on Outreach for STEM Oriented Students

I cannot prove the statement, but my thesis concerning the education of junior high school and high school students is
that genius (in terms of future success in a STEM field) is found evenly spread across ethnic backgrounds and economic backgrounds. A simple way to put this is that the "2 %" with parents who will take care of them whatever they want to do will be taken care of whatever one of us does or offers. Those without various opportunities are more likely be found in the 98% who lack opportunity because of background, inadequate financial resources or other factors. What ever percent of the 2% turn out to be geniuses, 50 times that many, by virtue of raw material with which they were born, lie in the 98%. Resources spent on the 98% are more likely to show outcomes that can be verified (in terms of evaluating various programs).

There are various problems, of course, including sparse resources to reach the 98%, evaluating programs for success in leading students into STEM fields (if they have the talent) and avoiding basing funding decisions on inadequate evaluation. My experience tells me that if one wants to know if a program worked in general, one must find the students who went through a certain program, after they reach the age of 40 and find out what has happened to them. Such tracking does not exist as far as I know, though long term studies by jobs economists may be underway.

My approach has been to find talented students who lack opportunity, bring them together for a few weeks of working together on a collaborative project and making sure they get guidance on courses to take and on other critical decisions that are essential to success in STEM but about which they may have no peer guidance or family encouragement.

A way to find such students is to ask teachers, who understand talent. Then, have teachers join those students in the summer program and have the teachers and students become co-learners, working together. This approach is very hard for teachers, I find, but it works. The plethora of resources on the web from science projects is the new development that makes this approach possible. While it emphasizes understanding over "getting ones hands dirty with equipment", one has to start somewhere. I find that there are many more teachers capable of leading such efforts than are capable of leading telescope construction projects, and it costs less. Futhermore, knowledge of how to build telescopes is not as widely applicable to the many choices a young person has as they mature, as is the knowledge gained from actually working with data.

Using the Sloan Digital Sky Survey as a teaching tool, students can learn to understand, on their own, the difference between meaningful data and noise (or glitches), the concepts of classification, the vastness of the numbers of both objects and categories of objects, and how to tell the objects apart. And, they can come to understand how inadequate is our knowledge of complete samples and therefore how much of our knowledge of the Universe is contingent on accidental discovery.

A staff capable of introducing students to software, judging the value of reference sources, and evaluting the new tools that are constantly arising is a necessity. Likewise, taking care of the management of the program, feeding students and dealing with parents requires time and talent. One advantage of the above program is that discipline is a non-issue: the teachers know their students and the students know the teachers and will see them in a new light as they learn together. A group of 30-40 students can be managed with a staff of about seven and school teacher per four students, plus a grad student for each two or three groups and a professional astronomer to guide the (self) instruction.

I spend a week giving the students the basic knowledge of astronomy needed including the teachers and three weeks letting the students work as in teams of four, gathering data for one large project. Each group gathers data from one part of the SDSS. In the last week, the student teams gather all the data from all groups and reach some conclusion on the specific project. For instance, what fraction of galaxies harbor massive black holes.

Apart from learning about science and basic steps involved in carrying it out, students learn the value of and need for software in handing big data, are exposed to the many components of large datasets, obtain career advise from discussions with staff and teachers and learn the value of open data and teamwork.

The Importance of Computation in Astronomy Education

M. Zingale[1], F.X. Timmes[2], R. Fisher[3], B.W. O'Shea[4]

Executive Summary: Computational skills are required across all astronomy disciplines. Many students enter degree programs without sufficient skills to solve computational problems in their core classes or contribute immediately to research. We recommend advocacy for computational literacy, familiarity with fundamental software carpentry skills, and mastery of basic numerical methods by the completion of an undergraduate degree in Astronomy.

We recommend the AAS Education Task Force advocate for a significant increase in computational literacy.

We encourage the AAS to modestly fund efforts aimed at providing Open Education Resources (OER) that will significantly impact computational literacy in astronomy education.

1 Computational Needs in Astronomy & Astrophysics

Computational skills are required at all levels of education and research in astronomy. Theoretical astrophysics is dominated by simulation instruments, often written in compiled and interpreted languages. Observational astronomy is entirely digital, with software pipelines for reducing and analyzing data. Community tools, such as the Python-based AstroPy[5], are actively developed for these pipelines. The workflow in astronomy is often expressed in UNIX-like environments such as OS X or Linux. Students in secondary or undergraduate programs may be unfamiliar with (and put off from) the command line and the job skills that it enables.

2 Undergraduate Education

Many astronomy and astrophysics programs encourage their majors to take some computer programming classes. For example, the State University of New York transfer path for physics requires an Introduction to Computer Science in the first 2 years[6]. However, this is where the encouragement of developing essential, transferrable job skills in computation frequently ends.

Astronomy students should be versed in elements of scientific computing and basic numerical analysis in astronomy courses that leverage community developed infrastructure. For example, Open Source web-based tools can be used to explore all stages of stellar evolution. Open data archives enable access to galactic and extragalactic data. These, and other, communuty developments offer educators outstanding opportunities to bring students directly into contact with real-world data, and to integrate data analysis and computation into the curriculum. Some examples of data-driven educational exercises include:

- Inferring the mass, radius, and density of the historic transiting exoplanet HD209458b
- Creation of a HR diagram from Tycho data
- Examination of stellar interiors using MESA-web
- Determination of the Hubble constant H_0 from Supernova Type Ia light curve data
- Analysis of gravitational waves from the historic binary black hole merger GW150914

We applaud the AAS's advocacy for increased literacy in scientific computation, as exemplified by the Hack Day events at recent AAS meetings. We suggest the AAS enhance its encouragement of sharing computational tools, educational lessons, and projects amongst their members.

[1] Stony Brook University [2] Arizona State University [3] U Mass Dartmouth [4] Michigan State University

[5] http://www.astropy.org/

[6] http://www.suny.edu/attend/get-started/transfer-students/suny-transfer-paths/pdf/transferSUNY_Physics.pdf

3 Graduate Education

A popular way to train graduate students in specialized codes and techniques used in each astronomy discipline are summer schools and workshops. We encourage the AAS to:

- Extend and promote these training sessions in association with the AAS meetings. For example, the Software Carpentry[7] sessions at recent AAS meetings are an excellent example of this training, and there is significant potential to further expand upon these sessions.
- Offer software instrument-specific training sessions at the AAS meetings. For example, "Best practices for CLOUDY[8]", "Introduction to MAESTRO[9]", or "Advanced yt[10]" can provide critical training and community networking opportunities for graduate students.
- Organize instructor training sessions for Software Carpentry, to facilitate participants offering these workshops at their own institutions.

4 Open Source and Open Education Resources

Open Education Resources (OER) are freely accessible, openly licensed documents and media for teaching, learning, assessing, and research. OER are among the leading trends in education, yet there is a paucity of quality material for astronomy. A few notable exceptions include: (1) astroEDU[11], which launched in February 2015, targets K-12 and is supported by the IAU Office for Astronomy Development; (2) the Astrobetter Wiki[12], which include links to user-contributed class slides, animations, texts, and other resources; (3) open-licensed texts such as the Open Astrophysics Bookshelf[13] and others[14]; (4) MESA-Web[15], a web-based portal for stellar evolution aimed at secondary and undergraduate education; and (5) IPython/Jupyter notebooks for deployment of interactive computation-based exercises.

- We encourage the AAS to modestly fund efforts aimed at providing OER material that will significantly enhance the use of computation in astronomy education.

5 Careers

Computational skills and critical thinking are among the most transferable job skills that an astronomy education can provide. We encourage the continued advocacy by the AAS for increased computational literacy, exemplified by the Hack Day events at recent AAS meetings, to provide skills that employers consistently seek.

[7] `http://software-carpentry.org/` [8] `http://trac.nublado.org` [9] `http://boxlib-codes.github.io/MAESTRO/`
[10] `http://yt-project.org/` [11] `http://astroedu.iau.org` [12] `http://www.astrobetter.com/wiki/Wiki+Home`
[13] `https://open-astrophysics-bookshelf.github.io` [14] `http://www.pa.msu.edu/~ebrown/lecture-notes.html`
[15] `http://mesa-web.asu.edu`