

Inspiration is “Mission Critical”

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Abstract. In spring 2013, the President’s budget proposal restructured the nation’s approach to STEM education, eliminating ~\$50M of NASA Science Mission Directorate (SMD) funding with the intent of transferring it to the Dept. of Education, National Science Foundation, and Smithsonian Institution. As a result, Education and Public Outreach (EPO) would no longer be a NASA mission requirement and funds that had already been competed, awarded, and productively utilized were lost. Since 1994, partnerships of scientists, engineers, and education specialists were required to create innovative approaches to EPO, providing a direct source of inspiration for today’s youth that may now be lost. Although seldom discussed or evaluated, “inspiration” is the beginning of lasting education. For decades, NASA’s crewed and robotic missions have motivated students of all ages and have demonstrated a high degree of leverage in society. Through personal experiences we discuss (1) the importance of inspiration in education, (2) how NASA plays a vital role in STEM education, (3) examples of high-leverage educational materials showing why NASA should continue embedding EPO specialists within mission teams, and (4) how we can document the role of inspiration. We believe that personal histories are an important means of assessing the success of EPO. We hope this discussion will lead other people to document similar stories of educational success and perhaps to undertake longitudinal studies of the impact of inspiration.

1. Introduction

Our discussion is motivated, first, by the unexpected retraction of funding for NASA’s education and public outreach (EPO) programs, including money already awarded to missions such as the James Webb Space Telescope (JWST) and the asteroid sample return mission (OSIRIS-REx). In March/April 2013, program leaders like us were told EPO was no longer “mission critical” and that our science teams should not even volunteer to do education in NASA’s name. Ironically, until then, an EPO component had been required of all mission proposals at 1–2% of mission cost and had been a rigorous part of proposal evaluation.

A second motivation for this discussion concerns what NASA does best: inspiring people, both young and old! While developing its 30-year long-range roadmap for astrophysics (Kouveliotou et al. 2013), NASA acknowledges that “These quests and missions will inspire the nation and the world, as NASA has done since its inception. The excitement of astrophysics and the challenges of space draw students at every level

into science, mathematics, and engineering, helping to build the expert workforce required for success in the global economy.”

Unfortunately, this aspect could be significantly curtailed due to the proposed cut-backs with negative, long-term consequences. We believe that NASA missions are uniquely effective at inspiration, especially among youth; that scientists and education specialists should team together for maximizing this benefit and achieving effective EPO; and that we should do better at both promoting and assessing inspirational value instead of relying on simple metrics such as the number of people served or the number of pictures and videos distributed, as is done presently via the OEPM (Office of Education Performance Measurement).

2. Panelists

Leading the discussion were Ms. Edna DeVore (Director of Education and Public Outreach of the SETI Institute), Mr. Ross Dubois (Program Coordinator and educator for the OSIRIS-REx mission), Dr. Larry Lebofsky (astronomer and Senior Education Specialist at the Planetary Science Institute), and Dr. Don McCarthy (astronomer and educator at The University of Arizona and Director of NIRCams’ EPO program).

Each person has had close, personal involvements in space exploration and associated EPO. In addition, each person works closely with other scientists, mission engineers, and the general public, providing a broad perspective on the impact of space science. During the discussion, each participant first spoke about how he or she was inspired towards science, technology, engineering, and math (STEM) and then described how team members and colleagues became motivated towards space science.

The wide variety of experiences described below by our panelists suggests that EPO will be most effective when diverse opportunities are made available to the public and when scientists and education specialists work together to implement EPO plans.

3. Inspiration

Inspiration is a necessary precursor to education and elevates us from the first stage of learning (“unconscious incompetence,” Adams 2011) along a conscious journey to competency and mastery of a topic or field. Perhaps because inspiration is harder to measure than the “number of people served,” it is usually ignored in program planning and assessments. Its effects typically emerge years later almost by accident through anecdotal stories.

Clearly, NASA missions continue to inspire the world. In the past year we experienced Mars Curiosity’s “Seven Minutes of Terror.” Now, on the 45th anniversary of Apollo 8, we can look back on the importance of the “Earthrise” photograph shot on Christmas Eve from the Moon. Ironically, the inspirational value of this single, spontaneous image is priceless and cannot be assessed quantitatively. It has been labeled “the most influential environmental picture ever taken” (Rowell), and it may represent the most valuable long-term benefit of 50+ years of space exploration.

“Inspiration” may seem too subjective to budget or to assess in short-term statistics, yet future missions will undoubtedly continue inspiring new generations in unexpected and ultimately powerful ways. To maximize this essential benefit, we believe

that NASA mission teams should continue their education programs, include EPO specialists, and find ways to promote and assess inspiration.

4. Don McCarthy

As a 3rd to 5th grade student, Don was inspired by the start of the world’s space programs and by the Olympic Games of 1960. Also in 1957, two bright comets (C/1956 R1 Arend-Roland and C/1957 P1 Mrkos) became visible, the International Geophysical Year began, and the solar cycle reached its maximum with aurora easily visible. In 1960, Don watched the Echo 1 satellite in the night sky and continued to follow all missions (manned and unmanned) to the Moon and nearby planets. He strove to be an astronaut in his studies, majored in physics, and received his Ph.D. in astronomy with the aim of becoming a Mission Specialist on the Space Shuttle.

4.1. NASA Astronaut Selection

In 1977, Don reached the finals of the initial astronaut selection for the Space Shuttle. Out of ~10,000 applicants, he was one of ~120 invited for a week of interviews, and eventually 35 of those were selected, including Sally Ride. An unexpected outcome of the astronaut selection process was that NASA had not realized the positive influence that Mercury/Gemini/Apollo had on a new generation of students. In the words of Mr. George Abbey, who led the interview process:

“What really came through in all the interviews is that this is the first selection we’ve had where we have been able to allow people who grew up with the space program to compete for astronaut positions. These individuals had made up their minds they wanted to be astronauts in the early 1960s when they were in grade school, junior high school or high school. They have been dedicating their lives to just that vocation, and everything they have done and all their accomplishments have been [keyed] to trying to put themselves in a better posture for an astronaut position. Consequently we have got a lot of well-qualified, extremely competent people both in the pilot and mission specialist categories.”

4.2. Astronomy Camp is “Life-changing”

Since 1988, Don has led an educational program for teens, adults, and educators known as Astronomy Camp. The Camps motivate students to continue their education in science, math, engineering, and technical fields, not necessarily to become scientists. Surprisingly, 12 students eventually received Ph.D.s in astronomy from different institutions, and 11 other alumni are pursuing Ph.D.s in astronomy.

Parents often ask how a week-long Astronomy Camp can be so “life-changing” and “inspiring” to their teenagers. Educational research (Fields 2009) reveals the significance of engaging in authentic scientific inquiry with peers of similar motivation, combined with mentoring from professionals.

The primary goal is to inspire each student and educator. For example, at every Astronomy Camp participants listen to, and discuss, JFK’s famous Space Speech from 1962, watch videos of experiments and astrophotography from Space Station astronauts, and participate in formal debates about the importance of NASA and future space exploration.

4.3. An Imperfect Model with High Leverage

In 2001, the NIRCam science team wrote its NASA proposal for the James Webb Space Telescope featuring an EPO partnership with the Girl Scouts of the USA (GSUSA). The team was concerned that curriculum materials for the existing Sky Search badge for Junior Girls contained major errors in fact and in basic astronomy concepts, thereby promoting misconceptions to millions of girls. Most likely, these materials were developed without the input of scientists or education specialists and were based on the premise that girls were not interested in doing science.

To correct these errors and to prepare a national audience for future discoveries by JWST, the team leveraged the experiences and facilities of Astronomy Camp to “Train the Trainers” in weekend workshops held twice per year. Until NASA’s funding was suspended in 2013, over 240 GSUSA volunteers and troop leaders had been trained in the STEM-related aspects of JWST and its scientific programs. Participants then applied their new knowledge to lead girls in their local troops in interesting scientific activities and observations. In honor of our ongoing partnership with the GSUSA, NIRCam’s beryllium optical bench is etched “Go Girl Scouts.”

The following reactions from participants demonstrate the value of including scientists and education specialists in our workshops.

“I always thought that science was just memorizing facts but you guys are encouraging us to think and explore. . .” (GSUSA adult leader)

“I’m not sure if you remember me, but I attended your first astronomy camp for Girl Scouts back in 2003 as a senior in high school. . . I can’t believe that was ten years ago! I have to say, that camp changed my life. I had always wanted to be an astronaut ever since I was a little girl but lacked the confidence to really pursue it. Can’t say that I’m one now, but I did end up graduating from the University of Arizona in 2009 with a degree in Engineering Management and a minor in Mechanical Engineering and am now active duty in the Air Force. Your camp. . . influenced my drive to be part of the women in science and engineering society.” (high school Girl Scout, ten years later)

4.4. Dr. Jeff Lockwood (curriculum developer for the Technical Education Research Center)

As a 17-year veteran high-school teacher of physics and astronomy, Jeff fell in love with astronomical research during a summer partnership (McCarthy & Lockwood 2013). He went on to develop a formal course for his students in astronomical research using authentic data, and participating scientists, from NASA’s planetary missions. He created a national model for “research in the classroom” that led to the NSF-sponsored “Research-Based Science Education” program at the National Optical Astronomy Observatories (NOAO).

Jeff was surprised to discover that “Students believe that scientific research is identical to literary research. . . . They have no sense at all of what the scientific method is. To them, research is clinical, dead, and mostly involves digging up old information and using it to improve our lives.”

Erik Timmerman, now a scientific programmer at NOAO and formerly with the Phoenix Mars Mission and the Lunar Reconnaissance Orbiter (LRO), said: “That whole process was the first time I went off on my own, although with lots of support, to learn

about something I thought needed to be investigated. Dr. Lockwood’s class gave me confidence and direction to choose science as my career. His kindling of my love of science has turned into roaring fire for the pursuit of knowledge.”

5. Edna DeVore

Edna grew up enjoying dark skies and meteor showers near California’s Sierra Nevada mountains. As an undergraduate, she took courses in physics and encountered astronomy. During her career, she has been a researcher, planetarium director, teacher, curriculum writer, and a highly regarded advisor for national education policy. She co-directs major EPO programs for two NASA missions: SOFIA (Stratospheric Observatory for Infrared Astronomy) and the exoplanet discovery mission, Kepler. Edna was also part of the team of scientists and educators who developed the “Life in the Universe” curriculum materials for students in grades 3–9 and a new high school course, “Voyages Through Time.”

From DeVore’s experience, the best EPO for teachers, students and the public is facilitated by EPO specialists of many types embedded in the missions. These specialists are catalysts. They create research opportunities, engage students in using NASA data, create opportunities for people to obtain direct experience in the research environment, connect scientists with students, teachers and the public, and facilitate the flow of exciting discoveries to the public.

5.1. Project FOSTER (Flight Opportunities for Science Teacher EnRichment)

One of Edna’s most unusual leadership roles was as Principal Investigator and Project Teacher for NASA’s Flight Opportunities for Science Teacher EnRichment (FOSTER; 1992–1996). FOSTER was NASA’s first Science Missions Directorate funded EPO program. It enabled 70 teachers to be trained and to fly with researchers in the Kuiper Airborne Observatory during science missions. Embedding teachers in the research environment fostered experiential learning that impacted their teaching practices and their students (DeVore 1995). Subsequently, the lessons learned with the FOSTER program informed the development of the Airborne Astronomy Ambassador program for NASA’s current-flying infrared observatory, SOFIA (Stratospheric Observatory for Infrared Astronomy), which also trains teachers to participate in research flights.

One of those FOSTER pre-college teachers (Dr. John Keller), who was inspired by a FOSTER experience in 1993, was in the audience of this panel discussion. In his words (Keller & Williams 1995), “Without FOSTER or Edna DeVore, we would not have had as strong a motivation to explore connections. . . FOSTER provided more relevance to our teaching at the different grade levels, as well as a better understanding of astronomy and NASA. It has also allowed us to relate these experiences to our students in discussions regarding science, the nature of science, and pursuing science beyond high school.”

5.2. A Model Program: FOSS (Full Option Science System)

For NASA’s Kepler Mission, the EPO team (SETI Institute and Lawrence Hall of Science in collaboration with NASA) worked to embed Kepler in the FOSS middle school curriculum. The FOSS “Planetary Science” unit for middle school was developed by the Lawrence Hall of Science, University of California–Berkeley, in collaboration with

Kepler scientists and education specialists. It incorporates authentic science and discoveries from the Kepler Mission, and provides model light curves that students interpret to discover exoplanets. The FOSS curriculum is used in all 50 states by over 100,000 teachers and two million students; it is in about 16% of the nation's school districts. Significantly, FOSS is adopted in 50 of the 100 largest urban school districts and thus reaches large populations of underserved students. Thus, via a partnership with a commercial product, the Kepler Mission can reach into classrooms and bring NASA discoveries to students and teachers.

In contrast to the Girl Scout's initial Sky Search material mentioned above, the FOSS program shows how scientists, engineers, and educators can partner to produce effective, challenging, and fun educational materials.

6. Ross Dubois

Ross grew up just south of Boston, Massachusetts, where as an 11-year-old he enjoyed exploring the night sky and began fiddling with telescopes. He would travel with his family to the Boston Museum of Science and to the McAuliffe Center in New Hampshire whenever new exhibits opened. In the late 1990s, he read about every NASA mission using the Internet as the place to find information. Later he earned a bachelor's degree in Space Science at the U. Mass. and his M.Ed. Degree in Secondary Education at the University of Arizona. As a Nightly Observing Program Guide at Kitt Peak, he introduced many visitors to the beauty of dark skies.

In his current role with NASA's OSIRIS-ReX mission, Ross is involved with Communications and Public Engagement. Below he describes how three of his colleagues became inspired by NASA.

6.1. Dante Lauretta (Principal Investigator of OSIRIS-REx)

Dante studied Oriental Studies, Math, and Physics as an undergraduate at The University of Arizona. He took advantage of an opportunity to work on a logic-based language for the SETI Project with funding from the University of Arizona's NASA Space Grant Internship. This experience sparked an interest in planetary science, and he went on to study planetary sciences and began working on the concept for an asteroid sample return mission.

6.2. Peter Smith (Principal Investigator of Mars Pathfinder and of the Phoenix Mars Mission)

Peter witnessed Sputnik and went to college during the Moon Race. He was fascinated by science fiction and the idea of flying through the Galaxy. In college he had a student internship working with sounding rockets, and this experience became a stepping stone into a career as an imaging scientist and Principal Investigator of the Mars Pathfinder and Phoenix Mars missions.

6.3. Kirk Hendrick

Kirk contacted the OSIRIS-REx offices to do a high school project on asteroid mining. Along the way he became fascinated with asteroids and co-authored a paper with the light curve and phase curve for fast rotating asteroids. Kirk plans to continue working

with OSIRIS-REx during college, assisting with data from their citizen science project “Target Asteroids!”

7. Larry Lebofsky

Growing up in the Space Age, Larry wanted to be an astronomer. Like Don, he remembers seeing Echo 1 moving across the night sky. He wrote letters to the Mercury astronauts and to Yuri Gagarin. He also wrote to Clyde Tombaugh for advice about becoming a “professional astronomer.” Years later, Reta and Herb Beebe were organizing Clyde’s papers and came across a letter written to him from an 8th grade student in Milford, Connecticut in 1961, i.e., Larry! So, Larry now has a copy of the original letter he wrote as well as Clyde’s response, annotated (33 years later) by “I see that you made it. Congratulations.”

As a student at Caltech, Larry got to observe with the Mt. Palomar 200” Hale telescope, then the largest in the world. One summer he was employed by Dr. Bruce Murray and helped develop and examine images taken by the Mariner 6 and 7 spacecraft when they flew by Mars. In his career as a planetary astronomer, Larry discovered water of hydration on asteroid Ceres. His long-term involvement in science education developed quickly after realizing that one of his educational videos for NASA (“Our Solar System”) was used nationally at all Chuck E. Cheese pizza restaurants, a wider distribution than his discovery paper about Ceres!

Below Larry describes several former students and educators who became inspired by his work and went on to become researchers and educational leaders.

7.1. Dr. Thea Cañizo (Senior Education Specialist, Planetary Science Institute)

As an elementary school teacher, Thea was a participant in Larry and Nancy Lebofsky’s NSF-sponsored Project ARTIST (Astronomy-Related Teacher In-Service Training) workshop. In her words: “You know what I think really got me started in leadership? [It was when] you and Nancy took me to the first NSTA conference in Kansas City. It was there that I got a sense that I was part of a profession with importance. Before that I thought more at the classroom and school level. That new perspective was part of how I got the idea I wanted to use for my dissertation—Teachers as Leaders.”

Thea went on to become the Middle Science Specialist for Tucson Unified School District and led the middle school science adoption for the district. She wrote several articles highlighting astronomy activities and eventually went on to get her Doctor of Education Degree. Now retired, Thea still teaches at The University of Arizona and coordinates teacher professional development and outreach workshops at the Planetary Science Institute, still working with Larry Lebofsky.

7.2. Dr. Susan Benechhi (Associate Research Scientist, Planetary Science Institute)

In sixth grade, Susan was inspired to be an astronomer after meeting Clyde Tombaugh, the discoverer of Pluto. Through Science Olympiad, she won a night on Kitt Peak with an astronomer. As a senior in high school, she spent two semesters being mentored by Larry, learning about asteroids and astronomy education. “I soon decided I wanted to get some experience in data analysis and Dr. Don McCarthy. . . provided me a number of research opportunities that have influenced the direction of my professional research

today (small bodies in the solar system: Kuiper Belt Objects, Pluto, comets and asteroids).”

During college, Susan’s research was sponsored through the NASA Space Grant program. She also participated in the Lowell Observatory REU experience (where she worked with Dr. Marc Buie). At graduation, Susan was awarded the Most Outstanding Senior award from the Department of Astronomy and a Presidential Scholarship to do graduate work at the Massachusetts Institute of Technology (MIT), where she received her Ph.D. under the direction of Dr. Jim Elliot. Susan is now a planetary astronomer specializing in the objects that first interested her in sixth grade, i.e., Kuiper Belt and Trans-Neptunian Objects. She is co-authoring a curriculum for high school students in home schools and Christian schools that teaches astronomy and addresses science/faith issues from a scientifically-accurate Christian perspective.

7.3. Michelle Higgins (Senior Director of STEM, Girl Scouts of Southern Arizona)

Michelle earned a M.S. degree in Physics. Through her volunteer work in the Girl Scouts she “realized that many young girls, and adults, did not understand the importance of math and science education.” She was shocked when her daughter’s friend said “I’m not smart in math. I’m just a girl.” The Girl Scout Council recommended that she attend the NIRCAM Astronomy Camp workshop for volunteers. In Michelle’s words: “This was a turning point in my career. This camp introduced me to others that also had a passion to educate young women and make an impact in their education choices. . . . I acquired hands-on activities and learned how to bring these (astronomy, Solar System, etc.) concepts to not only girls in my troop, but to share them with girls in Southern Arizona.” Spending the weekend with scientists, graduate students, and other volunteers sparked a life-long desire to pursue a career in science and math education for girls.

Michelle is on several advisory boards for programs that promote STEM education for girls and is the Director of ASTEC (Arizona Science, Technology, and Engineering Collaborative), a part of the NSF-supported National Girls Collaborative Project, and The University of Arizona STEM Learning Center.

8. Conclusions

These examples illustrate the importance of scientists and educators working together as partners in education and research. The underlying foundation of “inspiration” is evident: sometimes, just a single interaction, activity, or image can leave a profound legacy. Our stories derive from our personal long-term experiences accumulated in hindsight. More such stories are important to document and to demonstrate the value of NASA’s EPO effectiveness. We hope our panel discussion leads to efforts in that direction. Finally, it should be possible to assess inspirational benefits on shorter time scales as part of each activity and program, perhaps through common, strategic questions about changing attitudes and actions.

“The first men to orbit the Moon knew they were on an epic journey but they never imagined the impact of a single image” (Kluger 2013).

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