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NASA and Afterschool Programs:
Connecting to the Future

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Introduction

For nearly half a century, concerns about the quality of science education, literacy, and workforce preparation have spurred reforms in educational policy and practice. With the expansion of the afterschool arena in the past decade, serious attention is now being dedicated to understanding the potential contribution of this setting to engage young people in science, and to build their capacity as science learners and workers. Since its inception, the National Aeronautics and Space Administration (NASA), has made a substantial investment in education and outreach and now has a strategic imperative to "inspire the next generation of explorers." NASA supported the development of this project and report to examine the array of NASA educational resources and their use in afterschool, and to suggest directions that could strengthen NASA's educational investment in this arena to achieve outcomes valued by both the nation's science infrastructure and the afterschool educational community. The project was conducted by the American Museum of Natural History, (AMNH) an institution with a dual mission of science and education that has been intimately involved with afterschool programming for the past decade, in New York City and nationally.

The nation's science agencies are responsible for ensuring that the United States has a skilled workforce in science, technology, engineering, and mathematics (STEM) capable of meeting the demands of the 21st century. The workforce shortage in the United States is growing each year, yet the number of degrees awarded in STEM fields is decreasing annually (NASA, 2003). The Workforce Investment Act of 1998 recognized this growing problem, and included measures that increased the immigration quotas for highly skilled foreign workers and supported domestic programs to cultivate those skills among U.S. students.

Successful pursuit and entry into a STEM career requires: engagement (interest and initial involvement), capacity (the skills and knowledge to do science), and continuity (the opportunity and resources to move ahead to the next level of the educational and work system) (Jolly, Campbell, & Perlman, 2004). Among the contributing factors to the workforce shortage is the underrepresentation of women, minorities, and persons with disabilities in both science education and careers. This suggests that our societal and educational systems address engagement, capacity, and continuity more effectively for some members than others, and that central to the efforts to reduce the workforce shortage must be efforts to reduce underrepresentation.

For all the efforts that have gone into reforming science education and promoting participation, something is missing. Campbell suggests that while "we have convinced girls (and many boys) of the practicality of participating in science and mathematics,… we have failed to share our passion for these fields with them" (Campbell, 1997, p. 65). Selby (2003) holds that we have been doing a disservice to young people by teaching about a dissociated scientific method that is lockstep and separate from the person asking the question; that this loss

of the personal connection may not only discourage participation but create a misconception about the nature of science and the practice of scientific inquiry.

NASA and Afterschool Programs: Connecting to the Future argues that the afterschool arena is uniquely suited for implementing learning experiences that can contribute significantly to engagement, capacity, and continuity, and make that personal connection to science. The report is informed by an eighteen-month study and demonstration project that included a scan of existing science programming in afterschool, the development of prototype curriculum packets based on NASA resources, pilot testing and staff training in three afterschool programs in New York City, a review of science education research and promising practice literature, and consultations with experts in science education, afterschool, and curriculum development. This report looks at the strengths and resources of NASA and the afterschool community and finds that collaboration between the two communities could make important contributions to the creation of a competitive and diverse STEM workforce and a supportive, science literate population.

Section One sets the context and outlines the case for the NASA role in afterschool. Section Two provides and overview of the afterschool landscape, its complexity, commonalities, challenges, and assets. Section Three reports on the scan of the field, which looked at programs and materials targeting K-12 participants, supported by NASA and by the National Science Foundation (NSF). Section Four reports on the pilot testing of adapted NASA curricula in three demonstration sites in New York City. Section Five proposes recommendations for NASA to consider as next steps and areas for further exploration.

NASA and the Afterschool Arena: Background and Confluence

There is a confluence between NASA's goals and purposes and the goals and purposes of the afterschool and youth-serving communities.

Building on this, the potential exists for NASA and the afterschool arena to work together to provide a new generation of young people — who represent the increasing diversity of the nation — with the engagement, capacity, and continuity of educational experiences they need to join the STEM workforce.

Goals and Purposes of the Afterschool Community

The term "afterschool program" covers a wide range of activities, with different goals and practices. However, while these variations result in different emphases, most afterschool programs seek to:

Provide young people with safe spaces and caring relationships with adults. The parents of more than 28 million school-age children work outside the home, and 6.5 million of these children participate in afterschool programs (Afterschool Alliance, 2004). Providing young people with safe places to be and connections to caring adults are leading factors in reducing drug use, teen pregnancy, and school dropout rates (Miller, 2003).

Give young people the tools they need to become productive adult members of society. Afterschool programs provide opportunities for young people to develop their academic skills and to focus on other necessary life skills that are crucial to their success in adulthood. Afterschool programs support young people in their efforts to develop a sense of self worth, the ability to plan for the future, and attitudes of persistence, reflection, responsibility, and reliability (McLaughlin, 2002).

Give young people a space in which they can focus on their own interests, build on their own strengths, and have fun. Afterschool programs offer young people choices and the opportunity to discover and explore their own strengths and interests (Miller, 2003). Youth-centered programming responds to the diverse talents, skills, and interests of young people,

building on their strengths and providing personal attention in ways not possible during the formal school day (McLaughlin, 2002).

Afterschool programs have experienced rapid growth in the past 12 years, with funding from major private foundations and, more recently, from government sources. The increased attention being paid to afterschool programs today can be attributed to several trends:

Afterschool programs have recently undergone a period of expansion, driven by the need to support academic achievement in schools. Funding for the 21st Century Learning Centers by the U.S. Department of Education increased tenfold between 1992 and 2002, from a million to a billion dollars, accompanied by a much stronger focus on academic outcomes, accountability, and helping children perform better on assessments. Many afterschool programs now receive funds through the No Child Left Behind Act, as a means of providing supplementary educational services for failing schools. The increased emphasis on accountability and testing has spurred those who work with young people to seek ways to support student performance and, at the same time, to give young people an opportunity to explore their own interests.

Afterschool programs make a difference in the lives of their participants. Research shows that participation in afterschool programs reduces risky behavior, increases positive attitudes and behavior linked to success in school, and improves academic achievement (Hall et al., 2002; McLaughlin, 2002; Davis et. al, 2003; Miller, 2003; Hall et. al, 2004).

The freedom and flexibility of the afterschool setting allows for learning experiences not possible during the formal school day. With the expansion of high-stakes testing, schools have less and less time for subjects and activities that are not directly related to these assessments. Afterschool settings provide the opportunity for experiential learning that supports academic achievement, yet in ways that differ from the learning that happens in school. These programs offer time for long-term projects, opportunities to pursue individual interests, and strategies for connecting with the local community and its resources (McLaughlin, 2002; Miller, 2003). They also offer time for other experiences essential to healthy growth and development—physical activity, community action, creative arts, and play and fun.

Afterschool programs reach those who need extra support the most. Low-income and underserved minorities are enrolled in afterschool programs in greater percentages than the

population at large (Kleiner et al., 2004; Afterschool Alliance, 2004). Afterschool programs are most effective with those young people who are in the greatest need of additional support—young people from low-income families, or those with low school attendance, limited English proficiency, or poor test scores (Miller, 2003).

NASA's Goals and Purposes

Education programs are seen as "integral to every NASA activity" (NASA, 2005, p. 16). NASA is committed to cultivating the next generation of explorers, and its "Strategic Objectives for 2005 and Beyond" vows to "use NASA missions and other activities to inspire and motivate the nation's students and teachers, to engage and educate the public, and to advance the nation's scientific and technological capabilities" (NASA, 2005, pg. 8). This reflects and combines the two education-focused goals of its 2003 Strategic Plan:

> Goal 6: Inspire and motivate students to pursue careers in
> science, technology, engineering, and mathematics (STEM).
> Goal 7: Engage the public in shaping and sharing the experience
> of exploration and discovery.
> (NASA, 2003, pg. 20)

NASA's investment in education has been substantial, producing hundreds of educational products, including educator guides, posters, lithographs, and activity guides, and supporting thousands of one-time events and ongoing programs. Education is part of every field center's mandate. Science missions are required to have unique education and public outreach (E/PO) programs.

In recent years, NASA has expanding its work with the informal education community. NASA education and public outreach staff work with museums and planetaria, and are regular presenters at the annual conference of the Association of Science-Technology Centers (ASTC). NASA also partners with youth serving organizations such as the Girl Scouts and 4-H. In 2002, a Community-based Organization Working Group, within what was then the Office of Space Science, was charged with identifying potential national partners among major youth organizations. At the same time, AMNH launched the NASA and Afterschool Programs: Connecting to the Future project, coordinating its efforts with the CBO Working Group.

In 2003, education was elevated to the level of the other NASA science and technology enterprises. Subsequently, with the agency transformation in 2004, it moved to a headquarters-level office responsible for setting NASA's education agenda and coordinating the educational programming efforts of each of the science mission directorates. The addition of an Informal Education Division at

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the headquarters level and informal education officers at each of the NASA Field Centers signaled NASA's recognition that their assets could be useful beyond the formal and university environments, acknowledging science centers, planetaria, and youth and afterschool programs as effective providers of science learning and NASA activity whose potential had not yet been fully tapped.

The 2003 Education Enterprise Strategic Plan lays out four "pathfinder initiatives" meant to serve as the backbone of NASA educational programming. The Explorer Institute Initiative is the program for the informal science community. Its goals are to:

> Improve the public's understanding and appreciation of science, technology, engineering, and mathematics (STEM) disciplines to their scientific and technological literacy, mathematical competence, problem-solving skills, and the desire to learn;
>
> Establish linkages that promote new relationships between providers of informal and formal education, resulting in improved and creative STEM education in all learning environments;
>
> Excite youth, particularly those who are underrepresented and underserved, about STEM disciplines;
>
> Expand STEM informal education programs and activities to communities/locations that have been traditionally underserved by such opportunities;
>
> Stimulate parents and others to support their children's learning endeavors in formal and informal settings and to become informed proponents for high-quality, universally available STEM education in the home and elsewhere; and
>
> Encourage and implement innovative strategies that support the development of a socially responsible and informed public that can make responsible decisions about STEM policy issues affecting their everyday lives.
> (NASA, 2004, p.2)

NASA has a powerful capacity to inspire and engage the general public's interest in science. Its missions convey a great sense of optimism, adventure, and excitement. They connect us to cutting edge science and fundamental human questions. Space flight and exploration capture the imagination of young and old alike. Over 100,000 people attended Saturn observation events held by Cassini's volunteer network (Jet Propulsion Lab, 2005). The public responded to the recent Mars Exploration Rover mission with more than a billion hits on NASA websites in the first two days after landing (Edwards, 2004). The new Moon, Mars, and Beyond initiative exemplifies the spirit of exploration that drives human progress, continuing to fuel NASA's appeal to the public.

NASA brings a unique set of resources and opportunities to educational partnerships. The tag line "as only NASA can" recognizes those resources that NASA alone has to offer. NASA's operating principles for educational programs (NASA, 2003) call for all programs to connect to NASA **content**, **facilities**, and **people**:

> NASA missions explore our planet, our solar system, and our universe, connecting people to science **content** and open questions about the universe and our place in it.

> NASA **facilities** include the most advanced tools for exploring the universe, space-based telescopes and satellites, rockets, robotic explorers, space shuttles, and laboratories on Earth and on the International Space Station.

> NASA employs scientists, engineers, and support personnel who are passionate about scientific exploration and discovery. Sharing one's passion is among the most effective techniques for reaching learners of all ages (McLaughlin, 2002). NASA **people** can serve as inspiring role models for children and youth.

Confluence: NASA and Afterschool

The interests of NASA and afterschool programs converge by:
Connecting young people to the excitement of space exploration and scientific discovery — and to the passion of the women and men engaged in science
Building the capacity of young people to join the STEM workforce
Providing a continuity of programming that keeps young people in the STEM pipeline

Engaging Young People in Science: Connecting to Passion

> **NASA's** education efforts have often focused on helping **young people make a personal connection** with its resources, and presented science as an infinitely human and personal endeavor. NASA's educational content is awe-inspiring, its actual facilities can impress this technology-savvy generation, and its people are deeply committed both to their work and to conveying their excitement about their work to young people.

> **Afterschool** programs can help **young people discover who they are**, what they love to do, and how to pursue those interests

in school, work, and life. Giving young people exposure to adults who care, guide, and are passionate about what they do is a common and effective strategy in afterschool programs.

Opportunity for Collaboration: The recognition on both sides that **emotional engagement is crucial to learning** provides a foundation and sets a tone for collaboration between NASA and the afterschool community**.** NASA fires young people's imaginations and inspires their interest; afterschool exhorts young people to follow their dreams and get the preparation they need to do so. Together, NASA and afterschool programs can influence participants' attitudes about science, their ability to do science, and their determination to pursue science.

Building Capacity: Training the Next Generation

NASA, like much of the technical sector in the United States, is currently experiencing a workforce shortage (NASA, 2003). It is in NASA's interests, as well as the nation's interests, that the STEM workforce be increased to meet current and future demand. Research has shown that if women and minority men and women were participating in STEM disciplines at the same rate as their representation in the general population, there would now be a million more workers in STEM fields (Campbell et al., 2002). NASA's education objectives recognize that **building a diverse workforce is a crucial component in strengthening the STEM workforce at large** (NASA, 2003). Increasing the rate at which the underrepresented and underserved participate in STEM requires building the capacity of individuals to succeed in STEM coursework and participate in the STEM workforce.

Afterschool programs serve low income and minority young people at a greater rate than the rest of society. Thirty percent of African-American young people in grades K-8, 20% of Latino young people, and 23% of those identified as "other" are enrolled in center-or school-based afterschool programs, as opposed to 19% of all young people (Kleiner et al., 2004). Succeeding in STEM often requires overcoming low expectations by teachers, parental and societal beliefs about appropriate career paths, and individuals' own expectations, beliefs, and prejudices (Clewell & Campbell, 2002). Young people need these pressures to be acknowledged by others, and they need to be provided with strategies for overcoming them (NREL, 1997; NSF, 1991). Afterschool programs have been shown to build participants' resiliency, decision-making and problem-solving skills, and sense of themselves as competent learners. They also

offer opportunities to increase the involvement of family members in participants' lives and to build meaningful relationships with adults outside their families (Davis et. al, 2003; Hall et. al, 2002; Hall et. al, 2004; McComb & Scott-Little, 2003; McLaughlin, 2000; Miller, 2003). These outcomes that **provide learners with the strength, strategies, and support necessary to persist in STEM courses and career paths.**

Opportunity for Collaboration: Placing science instruction in afterschool settings embeds learning about science in a different context — one that offers the social and psychological support needed to **help greater numbers of learners overcome obstacles to participation in STEM careers**. When NASA involves young people in a program, it sends a message that the nation's leading science agency believes in their ability and is counting on them.

Providing Continuity: Keeping Young People in the Pipeline

NASA recognizes that a key component of creating a diverse workforce is the **establishment of a pipeline of programs** in which one feeds into the next so that young people who have had a good experience know where to go for more. The Education Enterprise Strategy (2003) identified four pipeline initiatives — Educator Astronauts, Explorer Schools, Explorer Institutes, and Science and Technology Scholarship Programs — intended to work together to provide a continuous source of programming for young people who are interested in science that spans from elementary school through college, both in and out of formal school settings. A challenge faced by NASA and other STEM stakeholder institutions is how they can turn programs that serve kindergarten through college students into a series that offers a logical progression for participants.

Some sectors of **the afterschool community can provide continuity**. Young people are often members at the same community-based organization for years or immediately join the local Boys & Girls Club or 4-H chapter in their new neighborhood each time they move. Community-based organizations inspire strong loyalty in their participants and participants' families. Some organizations often offer a clear progression that takes children from their elementary years through youth employment programs to staff jobs in the organization. Afterschool organizations have the potential to set up longitudinal tracking systems to stay in touch with participants and offer them new opportunities as they arise.

Opportunity for Collaboration: **Afterschool programs** are another learning environment that **can be built into a NASA supported STEM pipeline** of programming.

Connecting to the Future: The Potential for Collaboration

NASA educational programs, materials, and resources take participants to the frontiers of the imagination and science. They address questions that are intrinsically compelling, in expanding fields that hold the promise of interesting and lucrative jobs. NASA's imperative to build and strengthen the STEM workforce provides real opportunity for the next generation. Afterschool programs are a promising arena for preparing the next generation with experiences that use NASA people, facilities, and content. NASA and the afterschool community can build upon their common understanding of the importance of passion and inspiration to learning, and join their complementary resources and areas of expertise. Working together, they may be able to engage interest, support passion, build capacity, and offer the continuity necessary to contribute to STEM workforce participation.

The Afterschool Landscape

The afterschool arena encompasses a wide range of types of educational experiences, settings, program designs, and support infrastructures. In this section, we provide a starting point for those unfamiliar with afterschool program environments, drawing on the extensive research that has been conducted on afterschool programs to identify key issues and complexities that characterize:

Afterschool program participants
Afterschool community program profiles and support structures
Afterschool staff
Characteristics of successful afterschool programs
Outcomes of successful afterschool programs
The past and future of science in afterschool settings

We conclude with the challenges facing the integration of science into afterschool programs. The afterschool community needs programs that acknowledge and address these realities.

Afterschool Program Participants[a]

Recent large scale data collection efforts by the Afterschool Alliance (2004) and the National Center for Education Statistics (Kleiner et al., 2004) provide insight into the demographics of afterschool programs:

A significant percentage of young people participate. Eleven percent of young people in grades K-12 participate in some form of afterschool program (Afterschool Alliance, 2004).

Elementary and middle school aged children participate in afterschool at a higher rate than do ninth through twelfth graders. Fifty percent of children in kindergarten through eighth grade have regularly scheduled, non-parental care arrangements afterschool. Nineteen percent are enrolled in community center- and school-based afterschool programs (Kleiner et al., 2004).

The demand for afterschool programs is significantly greater than the field can currently support. Thirty percent of those

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[a] The term "participant" refers to the young people whom afterschool programs serve. Participant is used rather than "student" to emphasize that the majority of afterschool programs seek to differentiate themselves from school.

parents with children between kindergarten and twelfth grade not enrolled in afterschool programs said they would enroll their children if affordable programs were available (Afterschool Alliance, 2004).

Community center- and school-based afterschool programs serve low-income and minority children at a greater rate than the general population. Nearly thirty percent of African-American young people, 20% of Latino young people, and 23% of those identified as "other" in grades K-8 are enrolled in center- or school-based programs (Kleiner et al., 2004).

The demand for increased afterschool services is higher among minorities and low income families. Ninety-six percent of working parents pay the full cost of afterschool care, and for low-income families, this can be as much as 35% of their household income (National Catholic Reporter, 2003). Fifty-three percent of African-American parents and 40% of Latino parents with children not enrolled in afterschool programs stated that they would enroll their children if affordable programs were available (Afterschool Alliance, 2004).

Afterschool Community Program Profiles and Support Structures

Any program that serves young people outside of the school day can be considered part of the afterschool community. This covers a wide range of programs offering a variety of educational experiences, which have developed from distinctly different roots. While not all-encompassing, the following broad categories provide a framework that can help make sense of the field.

Local affiliates of national youth-serving organizations: These afterschool programs are supported by a national organization that provides varying levels of structure and professional development for local leaders. They were established during the Industrial Revolution and the turn of the last century and include, among others, Boys and Girls Clubs of America, Girls Incorporated, YWCA of the USA, YMCA of the USA, National 4-H (part of the U.S. Department of Agriculture Extension Service), Girl Scouts of the USA, Boy Scouts of America, and Campfire USA. Some of these organizations are housed in their own permanent local locations and offer drop-in, recreational, or more structured programs (sometimes in the form of weekly meetings over the course of a 10-15 week cycle). Others, like the Girl Scouts, Boy Scouts and 4-H, rely on space provided by others and focus on individual skill building and group projects that can

Independent community-based programs: Care for school-age children is one component of programming offered by community-based organizations that provide multiple services, often also including job training, tenant advocacy, and English as a second language classes. The content of afterschool programs is determined by the organization's understanding of the needs of the local community, such as increasing literacy, addressing health issues, or building advocacy skills.

School-based programs: A model in which community-based organizations partner with schools has gained increasing acceptance in recent years. This approach seeks to provide high-quality, large scale, low-cost programs on school grounds, designed to foster participants' success in school. These programs are often supported by regional structures, either centered in the school district or independently, which fundraise and regrant funds to establish programs, bring together interested community-based organizations (CBOs) and schools, and provide professional development opportunities for staff. The After-School Corporation in New York City (TASC), Afterschool Matters in Chicago, LA's BEST, and New Jersey After 3 are all examples of regional intermediaries that support school-based afterschool programs.

Museum and other informal institution-based programs: Many informal science institutions, such as museums, zoos, and botanical gardens also have afterschool programs. These programs are often application-based and focused on the content and activities of the informal institution. Informal educators, scientists, graduate students and other professionals in the informal institution serve as instructors and administrators.

Programs may be offered before and after school, on weekends, during school vacations, as well as during the summer. In writing this report, we were urged to mention the potential of summer camps as appropriate locations for effectively putting NASA content, facilities, and people to use.

Afterschool Staff

Afterschool programs of all types rely on caring adults to facilitate and supervise programs, and support and interact with participants. These adults are referred to by a number of terms, including instructors, teachers, coaches, line staff, and group leaders. In this report, we use the term "afterschool leader" to refer to an

adult leading a group of afterschool participants. Research offers several insights about afterschool leaders that can inform our thinking about their role in science education.

Afterschool leaders come from a wide range of backgrounds. They may include high school and college students, credentialed teachers, specialists in a particular area such as art or sports, community volunteers, or professional youth workers with varying levels of experience and training (Kelley, 1999).

Effective afterschool leadership is more often associated with beliefs and attitudes than with training and skills. In effectively promoting learning in afterschool settings, research indicates that an afterschool leader's ability to form strong relationships with participants, and to support them in relating to each other and trying new things, outweighs the value of a leader's credentials or years of experience (Seidel et al., 2002; Miller, 2003). The diversity in background and experience that afterschool staff bring can be viewed as an asset, capable of helping young people rethink who they are and what they can do.

There is no central system on which afterschool leaders rely for professional development. Afterschool leaders receive training and professional development from a wide variety of sources (Kelley, 1999). Governmental agencies and child care licensing courses may provide training in health and safety issues.

- o Local cultural or educational institutions may provide training in curricula and pedagogy.
- o National organizations may provide training in specific initiatives or core practices to local affiliates.
- o Regional institutions such as the Partnership for After School Education in New York City (PASE) have formed to connect afterschool leaders to professional development opportunities in their areas.
- o National gatherings such as the National Afterschool Association's annual conference can bring together afterschool leaders for professional development opportunities.
- o Advocacy groups such as Aspira, the National Council of La Raza, and the Urban League may provide training in specific educational initiatives to affiliated community institutions.

Characteristics of Successful Afterschool Programs

The diversity of afterschool program activities, goals, and structures lead to different definitions for "successful" afterschool programs.   However, a common focus of research and evaluation within the afterschool community is the promotion of positive youth development. Positive youth development is a term commonly applied to an approach to youth programming that seeks to build upon youths' strengths, and to provide youth with the skills they need to transition into adulthood. The positive youth development movement of the 1990's shifted the youth program paradigm from one that sought to prevent problems, such as drug abuse and teen pregnancy, to one that sought to develop young people as individuals (Miller, 2003). It provided the afterschool community with definitions, skills, and success measures designed to enhance and capture the broad impact that afterschool programs can have on the lives of participants.

Research has identified the attributes and characteristics of afterschool programs that successfully promote positive youth development (Eccles & Appleton Gootman, Eds., 2002) and academic achievement (Miller, 2003). These include:

> **Physical and psychological safety:** Settings offer safe space and decrease confrontational peer interaction.
> **Appropriate structure**: Consistency in rules, boundaries, age-appropriate monitoring, and programming are key elements.
> **Supportive relationships**: Adult leaders promote good communication and provide caring and support for all participants.
> **Opportunities to belong:** Participants are included regardless of gender, ethnicity, sexual orientation, or disabilities, and have a place to explore who they are and how they connect to their community.
> **Positive social norms:** Programs establish rules and practices that encourage mutual respect and set high standards for behavior among participants.
> **Support for efficacy and mattering:** Programs value young people's input and include them in decision-making. They focus on improvement and meaningful challenge rather than on relative performance levels.

According to McLaughlin (2002), afterschool programs are effective intentional learning environments when they are:

> **Youth-centered:** Programs respond to the diverse talents of participants, build on strengths, choose appropriate materials for those strengths and talents, provide personal attention, and reach

out to the local community.

Knowledge-centered: Programs have a clear focus, quality content, and instruction, while also including intentional curriculum.

Assessment-centered: Programs offer learning activities that involve participants in cycles of planning, practice, performance, feedback, and recognition.

Common Outcomes of Successful Afterschool Programs

Research has identified some common outcomes of successful afterschool programs (Davis et. al, 2003; Hall et. al, 2002; Hall et. al, 2004; McLaughlin, 2002; McComb & Scott-Little, 2003; Miller, 2003). These include:

Reduction of negative behaviors: reduced juvenile delinquency, substance abuse, drop out rates, suspensions, vandalism and conflicts between participants

Increased development of attitudes and behaviors that are linked to school success: better school behavior, work habits, emotional adjustment, sense of efficacy, and conflict resolution skills as well as improved attendance rates, attitudes towards school, relationships with parents, and sense of belonging to program and community.

Improvement in academic performance: Increased rates of homework completion and quality, improving grades, better data analysis and writing skills, higher scores on achievement tests, reductions in grade retention and drop-out rates

History and Future of Science Learning in Afterschool Programs

The place of science content in afterschool programming is one that continues to evolve, particularly as governmental agencies develop their focus on science education initiatives.

Informal science education has had a place in afterschool organizations for the past twenty years. Spurred by support from the National Science Foundation (NSF) with its creation of the Informal Science Education Program in 1983, youth and community programs began establishing science education programs. Concurrent efforts by the American Association for the Advancement of Science (AAAS) sought to put science on the agenda of community-based and youth organizations by connecting these organizations to the science education and scientific communities, and by offering program development,

evaluation, and fundraising assistance. A number of national youth development and advocacy organizations were already engaged in science or soon became so (e.g., Girls Incorporated, La Raza, Girl Scouts of the USA, California 4-H, American Indian Science and Engineering Society, National Urban Coalition, National Urban League, ASPIRA), as the emphasis on science was consistent with their missions of the empowerment and preparation of young people. These efforts grew at a slow but fairly steady pace through the early 1990s, but science in out-of-school programs was still more the exception than the norm.

Major foundation initiatives in leading urban centers were joined by the U.S. Department of Education's 21st Century Learning Centers initiative, and the afterschool arena gained prominence in the development of educational policy. This rapid expansion during the past decade was made possible by a shift in public will and a concomitant allocation of taxpayer and philanthropic dollars.

o   LA's BEST (Better Educated Students for Tomorrow) was established by the city of Los Angeles in 1988.
o   The After-School Corporation (TASC) was established in 1998 with a $125 million challenge grant from the Soros Foundation.
o   The Mott Foundation spearheaded the research, demonstration and advocacy efforts that led to the creation of the 21st Century Learning Centers, which moved the U.S. Department of Education into a national leadership role with regard to afterschool programming.

Federally mandated national science testing and the STEM workforce shortage will soon bring science education to national focus. Beginning in 2006, the U.S. Department of Education's No Child Left Behind program will add science to those subjects that are assessed as part of national proficiency. In addition, the National Assessment of Educational Progress (NAEP), the benchmark that has guided the development of many state-level assessments, is undergoing its first revision since the mid-1990s. The anticipated 2009 revision will align the test with the current National Science Education Standards and our increased understanding of how people learn science. In response to these activities on a national level, state assessment of science is expected to change.

Issues Facing the Afterschool Community's Integration of Science Programming

Despite its history and growth, the afterschool arena is not yet stable. In considering NASA's investment, it is important not to overpromise what afterschool programs can deliver, and to recognize their constraints and limitations.

Diversity of goals. There is a range of opinion within the diverse field of afterschool and out-of-school programs about how they can best support young people. Is the role of afterschool programs to help students meet academic achievement goals dictated by the formal education system? Is it to ensure healthy development and space for open-ended exploration, reflection, creative and physical pursuits? Is it to awaken and nurture a sense of community responsibility and self-efficacy in making a difference? How closely aligned with the school day should afterschool programs be? How different in tone and content should they be? Should the afterschool program be part of a "seamless day" or a break from the previous six hours?

Staff turnover and preparation. Afterschool staff positions are low paying, have few benefits, and do not offer job security. As a result, turnover for these positions is high and staff preparation and background are extremely variable. Afterschool programs must recruit, hire, and train new staff on a regular basis. Afterschool programs must be designed so that new staff members can be quickly brought up to speed and function independently.

Limited budgets, space, and planning time. Despite an overall increase of funding for afterschool programs as a whole, budgets for individual programs are tight. This is due both to the competition for resources that cannot meet the demand, and a policy agenda to demonstrate that the per child cost can be affordable and thus supportable by taxpayer dollars. Scarce dollars go first to direct service, with little allocation for planning time in which to develop, extend, or evaluate learning experiences. Funds for materials are limited, and the supplies suited to hands-on science exploration may not be readily available.

The growth of afterschool programs has not yet been matched by a consistent level of quality across the field. This is still a field under development, and there is an unevenness in capacity to deliver high quality experiences and outcomes.

The afterschool community needs programs grounded in these realities that can build on its current assets and circumvent its weaknesses.

Connecting to the Future: Building on the Afterschool Community's Assets

The afterschool arena is growing. As afterschool programs become linked to school achievement, more programs are looking for quality academic programs and curricula. Science learning experiences offer the opportunity to provide participants with school-relevant programming, and still maintain the hands-on, experiential learning style that separates afterschool from the school day. Afterschool programs serve young people who are traditionally underrepresented in the sciences and they provide those young people with the resiliency and socio-emotional skills they will need to succeed in STEM careers. With programs and curricula grounded in the realities of the setting, the afterschool community can join in NASA's efforts to establish and maintain a pipeline of programming bringing greater numbers of diverse young people into the STEM workforce.

Potential of Current Efforts for Afterschool: A Scan of the Field

NASA and the National Science Foundation (NSF) currently fund a wide range of programs that offer potential benefits for the afterschool community. These programs use a variety of strategies to connect participants with the resources of the science community — strategies that have implications for the expansion of current program models in the afterschool community at large.

A scan of the current portfolio of funded programs provides the following insights:

A number of existing science-rich programs have potential utility for the afterschool community.

NASA programs are primarily designed for formal education settings and make assumptions about context and leader background that do not necessarily carry over to the afterschool community. Making existing programs and curriculum suited for the afterschool community will require adaptation.

NASA programs are primarily designed for participants who are middle school age and older. Adaptation will also be required to make existing programs and curriculum developmentally appropriate for the afterschool community's primarily elementary-aged audience.

The main strategy for addressing underrepresentation is to recruit target audiences. Other strategies for supporting and acknowledging the needs of underrepresented communities currently have limited implementation.

Existing program models vary in their implementation requirements. These variations have significance for the expansion and design of programs for the afterschool community.

These insights suggest that efforts to design and expand programs for the afterschool community should consider the needs of the participants, the experience and preparation of the adults available to lead, and the support structures necessary to sustain quality programming.

Scan of the Field: Design and Methodology

This section of the report reviews the strategies, curricula, and materials NASA and NSF-funded programs use to connect participants in afterschool settings to

the resources of the science community. It pays particular attention to the implementation requirements of existing program models and the implications those requirements have for program expansion in the wider afterschool arena.

NASA guides its educational programming with a set of operating principles that are codified in its 2003 Strategic Plan. These operating principles call for all programs to accomplish the following:

> Respond to a need identified by the education community
> Make direct use of NASA content, people, or facilities
> Contribute to attracting diverse populations to STEM careers
> Leverage efforts with appropriate partner institutions in design, development, and dissemination
> Implement an evaluation plan to document outcomes (NASA, 2003)

The scan of the field draws from the dimensions identified in the operating principles to ask these questions:

> Who is served by current programs?
> How do current programs make use of STEM people, facilities, and content?
> What roles do adult leaders play and what preparation is necessary to fill those roles?
> What support structures are needed to operate current program models?
> What efforts do programs make to broaden participation in STEM?

The scan's central questions were explored through a review of goals and program design elements for NASA- and NSF-funded programs serving participants from age five to eighteen, a scan of topics and age ranges covered in available curriculum resources, and a detailed look specifically at NASA curriculum resources.

The scan of the field includes 81 NASA-sponsored and 49 NSF-funded programs, targeting 5-18 year old participants. The NASA programs were identified on the education Web pages for each science and technology (S&T) enterprise (at the time of the survey, there were five S&T enterprises: Space Science, Earth Science, Space Flight, Aerospace Technology, and Biological and Physical Research), education web pages for each of nine NASA Field Centers, and the Space Grant Consortium Web pages from 50 states and Puerto Rico. The NSF programs, active in fiscal years 2003 and 2004, were funded through the "youth and community" area of the Informal Science Education Program (ISE). For the NSF programs included in this scan, the award information publicly available on the NSF website, consisting primarily of an abstract written by the awardees, served as the primary source of data. One hundred twenty-five curriculum abstracts identified through the Education Resource Information Center (ERIC) and 140 NASA curriculum resources identified through the same sources as the NASA program information were included in the scan.

In a database, we collected information on the provider, target audience, location, program goals, program structure/pedagogy, number of participants, stated links to national educational standards, and any program elements intended to address underrepresentation. All information collected was in the public domain, provided by the programs or funding agencies on the Internet or in publications. Categories in program and curriculum descriptions that related to program goals, elements of program design, and strategies for reaching underserved audiences were identified and coded. In the analysis or organization of data, however, no judgments of quality were made and no evaluative roles with respect to effectiveness were assumed. For more detail on the scan of the field methodology, see Appendix A.

Findings

NASA has produced a wealth of programs, materials, and strategies that will require varying amounts of adaptation for afterschool settings. Some overall patterns emerged that are useful for considering next steps by NASA and by the afterschool community.

1. Existing science-rich programs and educational materials have potential utility for the afterschool setting.

These programs provide experiential learning opportunities that engage learners in scientific questions and in giving priority to evidence in answering questions, make use of professional tools or techniques for collecting and analyzing data, and connect to both established scientific knowledge and the open questions driving today's investigations. Some examples of programs with potential utility for afterschool can be found in Box 1 below.

2. The majority of programs produced by NASA were designed for formal education settings.

While these formal programs may often employ pedagogical strategies appropriate to the afterschool setting, they may be at odds with the structure of afterschool in two ways:

> They are designed to fit into a cumulative science curriculum and reference the concepts and skills addressed in that curriculum.

> They may be predicated on having teachers/leaders with formal background in science.

For a complete listing of the NASA curricula included in the scan of the field, see Appendix C.

3. Distribution of programs along the developmental continuum is uneven.

The majority of programs were designed for participants of middle school age or older. The fewest number of materials available were for elementary age children, the dominant age group in afterschool. One explanation for this uneven distribution is related to the laudable effort to align programs with national standards. The links between NASA content topics and the standards are almost exclusively at the middle and high school levels.

However, there are also standards related to scientific inquire, scientific habits of mind, science as a human endeavor, and the connections between science and technology. These standards apply across the developmental age span, yet are often neglected during the school day. Curricula and programs could be designed for elementary school learners that use active NASA missions and researxh to address these standards.

Box 1: Example Existing Programs with Potential Utility for Afterschool

Mars Student Imaging Project: Linked directly to the Mars Odyssey mission and produced by the Mars Education Program of the Jet Propulsion Laboratory and Arizona State University, this program provided the opportunity and structure for students to design and conduct their own research about the surface of Mars using NASA data. Students designed their own research, submitted proposals, and were selected to either travel to the Mars Space Flight Facility in Tempe, Arizona to receive images and interact directly with the mission team, receive images and interact with the team via distance learning technology or use archived images to complete their research. The program provided teachers with guidance and support in creating and supporting student-driven inquiry experiences in their classrooms.

The GLOBE Program: One of the most well-known programs of its kind, GLOBE has a long history of recruiting teachers and their students in the collection and contribution of data to a world-wide database of scientifically valid measurements in the fields of atmosphere, hydrology, soils, and land cover/phenology. GLOBE provides training and curricular materials for teachers, data analysis tools over the Internet for students, and the opportunity for both to collaborate with peers and scientists from around the world. GLOBE is managed by Colorado State University and jointly funded by NASA, NSF, and the U.S. Department of State.

Life on Earth…and Elsewhere?: Developed by TERC for NASA, this curriculum for middle school students uses the context of astrobiology and recent developments in our understanding of the conditions under which life can survive to build student understanding of core science standards about the definition of life and its requirements.

Many of the materials designed for middle school learners could also be adapted for younger children. Over half involved hands-on activities or date collection experiences that centered on observation and explorations (as opposed to complex mathematical calculations). What distinguishes them as middle school activities is the language used to describe them and the depth of understanding expected of the learners; with adjustments to these dimensions, the activities will work well with elementary age children.

4. The first and most common strategy for addressing underrepresentation is to recruit targeted populations.

The majority of programs (70%) with explicitly stated strategies for addressing underrepresentation recruit targeted populations. Additional strategies for meeting the needs of those populations are implemented with less frequency and include:

> Incorporating instructional strategies demonstrated to be effective with diverse learners
> Printing materials in multiple languages and/or featuring scientists from underserved and underrepresented communities.
> Sharing planning and decision-making with leaders in the targeted community
> Pairing participants with mentors from underserved and underrepresented communities
> Providing training, support, and resources for mentors working with underrepresented and underserved populations

Examples of programs employing some of these strategies can be found in Box 2 below.

Box 2: Examples of underrepresentation strategies currently employed by programs:

Sisters in Science in the Community (SISCOM): An NSF sponsored program out of Temple University, this organization notes that it uses techniques shown to be successful with girls and enumerates them in its program abstract. They include: hands-on, inquiry-based sports science activities; involving families in learning activities; and connecting participating girls with mentors.

Coastal Communities for Science: A partnership between four Native Alaskan communities and regional scientists involves community elders in the planning of the program and in the instruction of the young people carrying out the research activities.

Entry Point: This program for people with disabilities provides training and support for mentors and coaching on how to make work places more accessible.

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5. Programs in the scan sorted into three general categories: activity-based programs, project-based programs, and internships/mentoring programs.

> **Activity-based Programs**: Participants take part in group learning activities designed to develop understanding of specific science content.
>
> **Project-based Programs**: Participants complete a group or individual project using STEM facilities and/or methodologies over an extended period of time.
>
> **Internships/Mentoring Programs**: STEM professional provides guidance and/or work experience for program participants.

These categories are distinguished by their strategies for connecting participants with the practice of science and their use of STEM people, facilities, and content. Table 1 summarizes the characteristics of the three program categories. These categories are useful in considering the implementation requirements of existing program models and the implications of expanding these programs to the wider afterschool community.

Implementation Requirements

Each category of program makes different demands with respect to the role and capacity of the adult leader, and what kinds of supports and infrastructure (coordination, training) are needed.

Role of the adult leader: One of the biggest challenges to offering science in afterschool programs is the uneven backgrounds of staff with respect to science content and pedagogy.

> In **activity-based programs,** the adult leader serves as the facilitator of the exploration process, introducing the activities, presenting the materials in ways that invite children to explore them, giving enough instruction but not too much, answering questions but more often asking them, spotting when a child is ready for the next challenge or tool that will propel the next insight, and making connections from one learning activity to the next. These programs require leaders who are comfortable with their own knowledge and confident that they can help children find answers, even if they don't have the answers themselves. Having formal science background may make the adult more able to guide the inquiry effectively, but it also may predispose him or her to shortcut the exploration in favor of a right answer (Hammer, 2004). Nevertheless, test results in the formal sector indicate that students in grades eight and above benefit the most

from teachers with a strong science background (NCES, 2000). This implies that these programs work best when the adult leader is either a professional science educator or an afterschool instructor with training in a specific curriculum.

Table 1. Scan of the Field Program Categories
A complete matrix of the programs included in the scan can be found in Appendix C.

Program type	Activity-based	Project-based	Mentor/internship
Description	Participants take part in group learning activities designed to develop their understanding of specific science content.	Participants complete a group or individual project using STEM resources and/or methodologies.	STEM professionals provide guidance and/or work experience for program participants.
Use of people, resources, content	Content is the primary connection to STEM. STEM professionals serve as curriculum advisors. STEM resources and professionals may be featured in curriculum.	Participants make use of STEM resources to carry out project. STEM professionals serve as project advisors. Connections to content made in the context of the project.	Connects participants directly to STEM professionals. STEM professionals' work sets context for connections to resources and content.
Role of adult leader	The leader serves as a teacher or facilitator.	The leader serves as advisor and manager for project.	The advisor helps participants in STEM career decision making, and serves as a supervisor for internship work.
Support structures	Support structures provide curriculum, instructor training.	Support structures provide project guidelines, advisor training, and access to specialized materials or equipment.	Support structures recruit, select, and match participants and mentors, and provide training, on-going support, and opportunities for reflection for participants and mentors.
# of programs included in	54	61	32

In **project-based programs**, the adult leader serves as an advisor for the project, rather than as an instructor. Leaders familiarize the group with the guidelines of the project, facilitate the group's work, train participants in specialized techniques, and either provide content support personally or connect the team to a STEM professional for specialized coaching/advising. Project teams are led by afterschool professionals in informal settings and by teachers in formal settings. The challenge here is that to provide a fairly robust science experience, the adult needs to have some comfort and familiarity with connecting participants with information about the core content, scientific tools, and relevant questions pertinent to the project. A principle of project-based learning is that the leader should have at least as powerful an interest in the question as the young people have (Seidel et al., 2002).

Mentoring/internship programs require coordination by a non-mentoring staff person. Careful recruitment, selection, matching, orientation, and preparation of the student are needed to ensure a minimum level of skill, and of the mentor to ensure an appropriate developmental approach and support structure. The mentor/student relationship requires monitoring both for positive learning and resolving potential problems. In many cases, students need ongoing support (skill development, reflection, work habits) in order to be useful and productive in their internship assignment (Crawford et al., 1999; Barab & Hay, 2001; Ferreria, 2001; Foster, 2001). Youth staff workers are often particularly well trained to support reflection and to guide adult/youth relationships. However, sometimes the adult needs to have sufficient science experience to know what the student will need to be able to function effectively in the research process. Adults who are graduate students or teachers may be better matches for these needs.

Supports and Infrastructure: High quality program implementation requiring sufficient support.

Activity-based programs have a variety of needs related to materials, training, and logistics. First, they depend on an adequate stock of science supplies, which means programs need the funds and the time to acquire the hands-on materials and a place to keep them — or staff willing to load them into cars or carry them on rolling suitcases. Afterschool schedules and spaces need to allow for set-up and clean-up time, and protection of classrooms from activities that may be messy.

The need for other supports varies in relation to instructor background. When instructors are science education professionals, curriculum choices, linkages, and course design

are generally carried out by the instructors themselves. However, when instructors are afterschool professionals without formal training in science education, a self-contained curriculum, written background support materials, and professional development training specific to the delivery of the curriculum need to be provided by the sponsoring program.

The support structure necessary for **project-based programs** varies with the end product the project is intended to produce. End products fall into one of the following categories: building a working prototype or actual device to perform a task or meet a set of criteria, presentation of a design concept, participation in a mission simulation, data collected for a working professional science research project, or a report on participant driven/designed investigative research. The advantage of projects is that there are usually external supports available:

- o Umbrella organizations for design projects usually sponsor competitions and provide training for advisors, guidelines for the challenge, standards by which entries will be judged, specific materials or guidelines for selecting materials, and venues for competition.

- o Data collection projects train participants to contribute data to active research projects, train adult leaders in the specific data collection protocols, and supply background information and learning activities that provide a context for the data collection.

- o Mission simulation programs are staffed by informal educators familiar with the roles participants will be playing and provide specific training for new staff members.

- o Participant driven/designed research programs connect teachers to professional facilities, providing guidelines and practice for accessing resources, and training in the type of research participants can conduct using the resource.

All **mentoring/internship programs** included in the scan have a central structure for recruiting, selecting, and partnering mentors and participants. Program support staff may also provide training for mentors, arrange some activities in which mentors participate with their mentees, provide guidelines for the number of meetings or hours per week mentors and participants spend together, and provide on-going support for participants. The research base indicates that mentoring programs are most successful when mentors receive training and ongoing support (Ferreria, 2001; Foster, 2001; Herrera et al., 2000) and when programs provide

structure and planning to facilitate interactions between mentors and young people (Jekielek et al., 2002).

Connecting to the Future: Expanding from Existing Programs and Models

NASA and NSF currently support a broad array of programs and curriculum materials that could be adapted to support science learning in afterschool settings. These programs use different strategies for engaging learners and offer different levels of capacity building for participants. The complete NASA portfolio of programs covers the full developmental age range of participants from elementary to college students, although the portfolio is biased toward participants of middle school age and above. Right now, these programs do not progress from one to the next. However, they do provide a basis on which to build a continuous pipeline of programming. Expanding upon existing models to build engagement, capacity, and continuity, while also tracking the effectiveness of individual programs and how each feeds into the next, would strengthen NASA efforts to engage and educate the public and to build the STEM work force.

Decisions about which programs to expand or which existing models to reference in new program development should consider:

> Who is the audience? Program design should reflect the age, background, and needs of young people enrolled in afterschool. Programs need to be developmentally appropriate, offer opportunities for young people to explore questions that interest them, and be school-relevant, but not necessarily school-like. Who is available to lead?   An accurate understanding of the background and capacity of the leaders working most directly with participants is crucial to designing successful learning experiences. Afterschool leaders see participants as active contributors to their own learning experiences, have enthusiasm for working with young people, and have good instincts about how to encourage young people to try new things. Background knowledge of science content is highly variable. In many cases, additional training and support in science content will be necessary.
> What support structures will need to be in place? Training, curricular materials, access to science knowledge and science experts can all work to build and support the capacity of afterschool leaders to serve as science educators. Sponsoring institutions need to assess their own capacity for providing this support in program design.

Keeping the answers to these questions in mind will allow the successful programs and materials that are already a part of NASA's portfolio to be expanded to greater numbers of participants through the afterschool community. Opportunities that used to be available to only the number of participants that a single NASA field center or science museum could support can, with the appropriate adaptations and support structures, be expanded to young people in community-based afterschool programs around the country.

Promising Directions: Lessons from the Demonstration Sites

The demonstration site component of the project explored the learning experiences of 5-12 year old afterschool program participants and their leaders in three afterschool programs implementing curricula built on NASA content and from NASA materials.

The primary lessons learned were:

Participants have a high level of interest in space science and particularly in those questions which address the origin and nature of the planet, the solar system, and the universe.

Giving participants the opportunity to express themselves offers a powerful platform for building scientific habits of mind and explanation skills.

In the context of research findings on the power of discussion-based science learning experiences, the demonstration project suggests that afterschool programs, building on the youth development strengths of its staff, can serve as a setting for instructional models centered on inquiry. Inquiry learning experiences in afterschool programs can connect participants to science and to NASA in ways that may not be possible in today's assessment-driven classrooms, but that are crucial for supporting young people's entrance and advancement in the STEM pipeline.

The Demonstration Site Component

The demonstration site component explored the realities of starting and supporting science programming in afterschool settings. It asked:

What science learning can happen in afterschool settings?
What science content and process skills should be the focus of afterschool science learning experiences?
How should science learning experiences be designed to best build on afterschool leader strengths?

The initial demonstration took place over a nine-month period from September 2003 to June 2004. To reflect the diversity of the afterschool community, we selected three different configurations of afterschool programs for the study. The selected configurations included afterschool programs run by 1) an independent community-based organization (CBO), 2) a public school collaborating with a community-based organization, and 3) a local affiliate of a national youth-serving organization. A total of six sites serving 240 students participated in the demonstration program. Table 2 summarizes the demonstration site profiles.

Each of the sites was provided with a packet of curriculum activities centered one of two themes ("Astrobiology" or "The Sun as a Star") that was adapted from existing NASA or AMNH curriculum developed for formal classrooms, often for middle school students. (For more about the specific activities used and adaptations made, see the related prototype curriculum packets also produced by this project.)

Table 2: Demonstration Site Profiles

	Independent CBO	School/CBO collaboration	National youth serving organization local affiliate
Description	Organization dedicated to revitalization of neighborhood Operates afterschool programs at multiple sites focusing on building literacy skills Demonstration project worked with one site	School and CBO partnered with support from a regional intermediary. School provides the academic portion of afterschool program — math skill building for students in need of remediation.	Local affiliate operates eight sites. Each site offers educational and recreational activities. Demonstration project worked with program providing academic support for underperforming students.
Age of participants	6-10 years old	8-11 years old	6-12 years old
Afterschool leader background	Leaders were high school students provided with 6 weeks of intensive youth development and literacy training.	Leaders were credentialed teachers.	Leaders were site education directors and part-time staff. Organization requires all education staff to pass a minimum competency test.
Program location and population served	Brooklyn, participants predominately Latino	Bronx, predominantly Latino and African-American participants	Five sites in Bronx, Brooklyn, and Queens — population predominantly Latino and African-American

Afterschool leaders and participants were engaged as co-researchers along with the AMNH staff. Observations and interviews with participants and leaders conducted by the AMNH were supplemented by leader session summary logs, participant journals, and embedded data collection activities in the curriculum that allowed leaders to elicit and capture participant thinking. Leaders at each site were trained in the particular curriculum activities to be implemented and in the data collection techniques. For more detail on our methodology see Appendix A.

Lessons Learned

While the demonstration did not provide conclusive answers to the broad questions it asked about the shape science instruction should take in afterschool settings, it did demonstrate that there is a place for science instruction in afterschool. The experience provided some interesting insights that suggest promising directions for future research and development in afterschool program design.

Lesson 1: Participants have a high level of interest in space science and ask "origin questions."

One of the primary concerns expressed by afterschool administrators and leaders in the demonstration sites was the fear that participants would not be interested or engaged in science learning activities. The project, however, operated on the assumption both that participants would enjoy the activities and that space science topics in particular are compelling to many young learners. In subsequent interviews, both program leaders and participants confirmed our assumptions and recounted (and recanted) earlier doubts that science activities might not be an appropriate use of their afterschool time.

Demonstration site participants seem particularly interested in what Gallas (1995) refers to as "origin questions." Young learners want to know where things come from, how they were made, what they are made of, and what's gong to happen to them eventually. In interviews, participants were encouraged to share their questions. Every interview with participants ended with an opportunity to share questions about space science. The range of topics covered by participant questions is represented in Table 3.

The science education community has long understood that the ideas that young people hold about science topics affects their learning of new topics. The classic example of this is the persistence of incorrect ideas about the causes of the seasons held by young learners (Schneps & Sadler, 1987). Gallas (1995) argues that understanding the science questions learners are asking — and how they relate to the persistence of preconceived ideas — is crucial to building effective curriculum. In the seasons example, Gallas suggests that learners may not be able to absorb new knowledge about the sun-earth system unless the explanation taps into the origin questions they have about the way the sun and the earth are related to each other.

Table 3.   Participants' Science Questions

Question topic	Sample questions
Life on other planets	"Is there life on every planet?"
	"Do aliens exist?"
How things were made	"How do people find planets?"
	"How was the earth created?"
	"How was the whole universe made?"
	"Who had the idea to make the planets?"
	"How was the earth created?"
What things are made of	"What are/is (stars, a comet, the moon) made of?"
Seeking explanation	"Why was the moon made?"
	"Why were the planets made?"
	"Do the moon and other planets move?"
Space travel	"How do astronauts get to Mars?"

Our demonstration site findings suggest some important questions to focus on are:

> What is the environment in space like?
> How and why is space different from Earth?
> How was the solar system formed and what is it made of?
> How do we learn about the environment of space?

Lesson 2: Giving participants the opportunity to express themselves is a powerful experience on which scientific habits of mind and explanation building can be built.

The qualitative approach we took to investigation sought to uncover participants' thinking and the range of their experiences with the learning activities. To facilitate this sharing, we embedded a number of activities in which participants shared their thinking and debated with other participants while leaders captured their ideas on large sheets of newsprint. Leaders were trained to focus on getting participants to articulate their thinking rather than to move them to one right answer. These data collection activities and the classroom discussions they sparked proved to be among the most fruitful and interesting activities for participants and leaders alike. In 85% of follow-up interviews, these activities were either the first activity participants described, or the first or second answer to the question "what were some of your favorite activities?"

The activity receiving the most mention in both participant and leader interviews was the first activity in the astrobiology sequence, a data collection activity that asked the groups to survey their own opinions about the existence of alien life. Alien life is a compelling topic for many people, so the popularity of this activity

was perhaps not surprising. However, the comments made by participants focused not on the subject matter, but on the act of talking and listening to others. "We got to hear what other people were thinking," "I liked talking," "I liked saying my opinion," and "You got to say some things that you really wanted to say for a long time," were typical comments made by participants describing this activity. This activity seemed to generate a spirit of discussion and debate that was carried on throughout the rest of the activities, taking participants beyond simply expressing their own ideas and opinions to group explanation and consensus building.

The two boxed vignettes illustrate the spirit of discussion and debate generated in the demonstration sites. The first vignette illustrates the stamina and persistence that participants had for group discussion in connection to science learning activities, and includes a group effort at explanation building. The second vignette illustrates the comfort and ownership some participants took in conversations about science, even when holding conversations with science "experts."

The leaders also noted the power in providing a chance for the participants to express their own ideas. Across the board, leaders from all program sites noted that any activity that involved discussion and the sharing of ideas was very successful with their participants. A teacher from the school-based program said "I don't normally get a chance to talk to my kids like this during the school day." Another shared that her students loved the science day (as opposed to the remedial math days that made up the rest of the afterschool program's week) and that she suspected that was primarily because they were encouraged to talk. One of the 17-year-old leaders from the community-based organization summed up her experience with the popularity of group discussion with the comment "Most of the time I find that if you just tell them stuff, then they lose interest, but when you ask them stuff, they like it."

The demonstration program leaders were not trained to take these discussions to a deeper level of content understanding. They were provided with techniques, activities, and practice in guiding participants to articulate their thinking, but not in building upon that thinking to further science learning. However, the potential for conversations of this kind to lead to deeper science learning can be found in the literature.

Three different research projects have looked at group explanation-building conversations — more elaborate versions of the brief discussion on whether or not the book was living in the first example above. Children as young as first grade (Gallas, 1995; Hammer 2004) and learners for whom English is a second language (Rosebery et al., 1992) have successfully participated in, learned from, and appeared to enjoy group conversations exploring their ideas about physical and natural phenomena. In all three cases (Rosebery et al., 1992; Gallas, 1995;

Vignette 1: Developing a Definition of Living and Non-living

Site/leader: Unaffiliated CBO, 17-year-old leader
Age range of participants: 9- and 10-year-olds
Number of participants: 10 (4 boys, 6 girls)

The leader tells the participants that today they will be comparing living and non-living objects. He asks the students to write "living" and "nonliving" on large sheets of paper spread out on each group's table. While the participants draw columns on their sheets, the leader places two objects on each table. Group 1 receives a book and a small stuffed deer. The leader tells the students in Group 1 to pretend that the deer is real. Group 2 is given a book and a Christmas tree ornament. Group 3 receives a flower and a small artificial Christmas tree. He asks the groups to discuss what makes the objects living or nonliving and record their criteria on the sheets of paper.

The groups begin to discuss what makes the objects living or nonliving. Group 2 notes that the book doesn't talk, that it doesn't have legs or a face. Group 1 debates whether "dead" and "non-living" are the same thing. Group three notes that the flower has cells. While each group continues with its own discussion, some students stand up and walk around to the other tables to see what the other groups are writing, hear their discussion, and report what they have learned from other tables back to their own groups. The individual group discussions continue for 20 minutes before the leader stops the students and asks each group to select one person to present the findings to everyone.

Each of the three groups takes a turn presenting their ideas about which items were alive and the criteria they used to make that determination. Group 1 has elected to describe the book as "dead." After all three groups have presented, the leader encourages participants to ask each other questions. A participant from Group 2 questions the claim of Group 1 that the book is dead, arguing that, "It's not dead because it was never alive anyways."   This revives Group 1's earlier discussion about the proper word to describe the book, and a debate whether the book is dead or was never alive begins between several participants. Some participants argue that since paper comes from trees and the book is made out of paper then this would make the book dead. Other participants say that the tree was alive but not the book. After several more arguments are exchanged back and forth, the participants agree that the tree from which the paper was made was alive but that doesn't mean that the book ever lived.

Vignette 2: Class Interview

Site/leader: School-based program, credentialed teacher
Age range of participants: 8- and 9-years-old
Number of participants: 9 (6 girls, 3 boys)

The participants in this interview started with the Sun as a Star materials, but abandoned those activities after the first two or three activities due to poor weather and the lack of playground access. They moved on to Astrobiology and completed those activities instead. AMNH staff members have come to conduct a closing interview with the participants.

The teacher reintroduces the class to the two AMNH staff members, describing them as "the NASA scientists from the museum" and telling the students it would be a good time to ask all the questions she hasn't been able to answer for them. The interview begins with the AMNH staff explaining that NASA is interested in hearing the participants' ideas and opinions about everything they have learned in the last few weeks, and that the questions they have are also of interest to them. As the participants are sharing their ideas about the sun, Nellie asks the question "Does the sun travel?" Rather than turning to the "NASA scientists" for her answer, she looks to her fellow students and the following, rapid fire conversation begins among the students

Nellie: Does the sun travel?
Elpida: The earth rotates around the sun. The earth goes around in a year.
Mary Beth: It goes around its axis.
Elpida: The sun goes around the earth and that's a year.
Mary Beth: Where does the sun travel, if the moon comes to provide darkness for the night?
Elpida: The Earth turns about to be night and then the moon, turns an invisible line — and then the earth moves to turn into night and then the other side of the world has day time.
Lashonna: I think the earth rotates around the sun, the moon stays around the other side and then the earth rotates.
Elpida: If we have seen the moon then…
Nick: What is the moon made of?
Dorian: How do you get noon, when the earth rotates how do you get noon? If it's night then…
Mary Beth: It takes 24 hours for the earth to rotate once. Maybe it's noon if the earth is not quite totally rotated, like maybe one-fourth rotate.
Sima: So the sun rotates?
Nick: What is happening at noon?
Mary Beth: Noon is in between the sun and moon.

The group breaks into many side discussions about the sun, the moon, day, night, noon, etc. Despite the presence of two AMNH staff members identified as experts by the leader, the participants are still comfortable expressing their own ideas and responding to each other's questions, and do not insist or even wait for the experts to provide answers.

Hammer, 2004) researchers identified what Hammer terms "the beginnings of scientific expertise" in these conversations: a sense of what it means to build explanation, to look for causal factors, to employ analogies, to connect to familiar experiences, and to look for consistent, mechanistic explanations.   The afterschool setting, where participants and leaders work together to build their understanding of science, may be conducive to developing these beginnings of scientific expertise.

Science as Inquiry in Afterschool

The demonstration project found that afterschool participants are engaged by and have many questions about space science. The demonstration project also found that providing opportunities to express their thinking and respond to the thinking of others is a powerful experience for participants upon which scientific habits of mind and explanation building can be constructed, and that afterschool leaders have the ability to lead these learning experiences. Taken together, these findings and research on conversation-based learner inquiry in informal settings suggest that an appropriate focus for science in afterschool is building an understanding of and an ability to participate in science as inquiry.

It is generally agreed by the science and education communities that an understanding of the process of science inquiry is a key component of science literacy (NRC, 1996; AAAS, 1993).   An important first step is to define what we mean by "inquiry." *Inquiry in the National Education Standards* (NRC, 2000) identifies five essential features of inquiry learning experiences:

1. Learner engages in scientifically oriented questions.
2. Learner gives priority to evidence in responding to questions.
3. Learner formulates explanations from evidence.
4. Learner connects explanations to scientific knowledge.
5. Learner communicates and justifies explanations.
(NRC, 2000, pg. 29)

Learning science *by* inquiry needs to be distinguished from learning science *as* inquiry (Hodson, 1988). When learning science *by* inquiry, students both learn the scientific process and "discover" the scientific knowledge that is the goal of the lesson along the way. Teaching science in this way requires a deep understanding of both content and children's developmental understanding of science. In an afterschool setting, where leaders rarely have either deep science background or extensive educational training, learning science *by* inquiry seems unlikely to succeed.

However, if we shift our content focus to developing an understanding of science *as* inquiry, we can build upon the strengths of informal learning settings and professionals to provide opportunities for learners to explore and refine their

own thinking about natural and physical phenomena as they develop scientific habits of mind. Focusing on science **as** inquiry requires teaching strategies that encourage participants to make their own ideas explicit, explore the implications of their ideas, match and test ideas against experience, use theoretical ideas to explain observations, and modify and refine ideas to match observations (Hodson, 1988).

One of the greatest obstacles to developing an understanding of science **as** inquiry is learning to build explanations from evidence (Kuhn, 1989). This obstacle is best overcome by providing learners with practice in moving from data to explanation (Duschl, 2000). Research has shown that young learners can develop their understanding of science as inquiry through group "science talks" or "inquiry conversations" (Roseberry et al., 1992; Gallas, 1995; Hammer, 2004). For "science talks" to work, the learners need to own the conversation — learner voices need to be more important than adult leader voices (Gallas, 1995; Hammer, 2004). Facilitators of inquiry must encourage participants to articulate and expand upon their thinking, and to listen and respond thoughtfully to the thinking of others. Group dynamics that value the contribution of all members must be established. It must be expected that all participants are capable of contributing to the group inquiry effort, and are in fact required to do so.

Successful afterschool programs recognize participants as important contributors to the programming, as opposed to passive recipients, and have an arsenal of strategies for guiding children to express their thoughts and ideas, listen and respond appropriately to each other, and to work together as a group (Davis et al., 2003; Hall et al., 2002; Hall et al., 2004; McLaughlin, 2000; Miller, 2003).The focus of afterschool on the importance of the voice of the young person, and the very fact that afterschool is not school, may make this environment particularly conducive to inquiry learning experiences. In the demonstration sites afterschool leaders from a variety of backgrounds gave the ownership of science conversations to participants, and which built the confidence of participants to the point that they were able to sustain that ownership even in conversations with AMNH staff members.   By linking these strengths of afterschool programs to the skills necessary to facilitate science inquiry, we can develop instructional models and materials that work to further both science learning and youth development goals.

The demonstration site findings demonstrate the potential for afterschool leaders to function as facilitators of inquiry without having an extensive science background or science teaching experience. The following excerpt from an interview with the 17-year-old leaders from the unaffiliated community-based organization provides a glimpse into this potential. In this excerpt, the afterschool leaders are discussing what they do when they do not know an answer to a question that a participant asks.

Excerpt from CBO staff interview

Sallie: Um-hm — what's getting harder is like, when they say that something's living or alive, and I don't know, I have no idea how to answer it. I just like change the topic because I have no idea how to answer it. Like they say "Is a tree alive" and I'm like, "oh, I don't know." So we were like, well, it needs air and it needs sunlight, and it needs water, but it hardly moves unless it's pushed, and it dies in the winter time. But like, questions like that...

Tom: That's exactly what my kids like enjoy. I told them that just because something has like legs, does that mean that it's alive, 'cause chairs have legs? That's what they enjoyed the most. Like that things don't have to be just like us to be alive. They really go into that.

Sallie: But, you always have to come down to giving them an answer.

Interviewer: And sometimes you feel like you don't have that answer?

Sallie: Yeah. So we just leave it like, everybody just stick to your own opinion.

Interviewer: How did the rest of you handle it when you get asked questions where you don't know the answer? Has that happened yet?

Tom: I forget what, but I know I played it off.

Al: I just say that you are all scientists in training. I've been saying that since the beginning. You're scientists in training so it's your job to find out. So, if I can't answer a question, it doesn't mean that I'm wrong, because scientists can't answer all questions yet either.

At first glance, Sallie's story about not knowing whether or not a tree is alive might seem to be an example of the dangers of placing science learning in afterschool: When she doesn't know whether or not a tree is alive, she claims that she just changes the topic. However, in her next sentence, she explains that what she actually did was get the participants to go back to the list that they generated and consider for themselves whether or not the tree was alive. She doesn't have a strategy for putting complete closure on the question, and she's uncomfortable with that, but her instincts were to go back to the evidence and ideas put forth by the participants. This is exactly the strategy used by facilitators of inquiry. Al is more comfortable with this approach than is Sallie. In this interview he explains an idea that he uses frequently in his work with participants: He positions himself as a scientist in training along with his participants, working together with them to build content understanding through inquiry.

Both Sallie and Al need strategies for connecting learner thinking to established scientific knowledge. Yet they have successfully led their participants through the rest of the essential features of science inquiry. Sallie and Al are not simply science novices. While they have little experience as science teachers and little content knowledge, they have had extensive youth development and literacy training.

Connecting to the Future: The Potential for Inquiry in Afterschool

Developing an understanding of science as inquiry is an important educational goal, and one that can deepen a learner's subsequent experiences with science in both formal and informal settings. If science instructional models can be built that tap into the skills that are already valued by afterschool programs and addressed in afterschool professional development, the potential for science instruction to be part of this arena can be more easily developed. Further research and development work needs to be done to fully develop instructional models, curriculum, training, and outcome measures that build upon the existing strengths and infrastructures of the afterschool setting.

Recommendations

The nation's science and technology interests, the advancement of science and the next generation can be well served by NASA and the afterschool community joining forces.

The recommendations for integrating NASA content, facilities, and people into afterschool are predicated on several underlying requirements for success. Making NASA educational resources is important and necessary, but not sufficient. Attention must be paid to building capacity and infrastructure as well as to dissemination and evaluation. Training, supplies, planning time, piloting, and refining new initiatives and strategic planning that can incorporate a new agenda are real costs that need budget lines and allocations. Along similar lines, changing young people's pathways and the capacity of educational organizations is not accomplished by quick fixes or single contacts. It depends on building a truly collaborative relationship. A partnership between NASA and the afterschool community will require sustained engagement and collaboration for the long term.

With these requirements in mind, we offer the following recommendations.

Recommendation 1: Make NASA resources fully accessible to the afterschool community

Adapt existing curricula for the afterschool community. Our scan showed that there are programs and curricula that are likely to fit well into afterschool programs. The demonstration program showed that some middle school curricula have the potential to be adapted for younger audiences. Further review and adaptation of existing materials would be most effectively done in collaboration with curriculum developers and afterschool partners.

Expand marketing and distribution of NASA materials beyond formal educators to include afterschool leaders and other informal science educators. Educator Resource Centers and a number of NASA competitions and programs are currently open only to "teachers." Redefine who has access and who can participate, and publicize and market the materials, competitions, and programs to the afterschool community. This can immediately enlarge the audience of users; if there are costs associated with producing additional print materials, provide the access on-line rather than in hard copy.

Target and work with organizations and networks that can serve as early adopters and effective disseminators of NASA resources. Start with

organizations that are receptive to incorporating science and have some level of infrastructure and capacity. Review the missions and philosophies of the organizations; those that have an explicit focus on career development, remedying unequal access to math and science, and connecting participants to resources are likely to see the utility of NASA goals and resources more readily. Select partners from the national youth organizations with which NASA has already taken the initiative, such as Girl Scouts of the USA and 4-H, and from regional afterschool coordinating organizations that provide professional development and program implementation support to their members.

Recommendation 2: Extract and concentrate on the NASA content that is most appropriate for afterschool science

Focus on building understanding of the nature and practice of science.
NASA's greatest asset to science education is its leadership in active science and engineering research. NASA content aligns well with standards about the nature and practice of science; it aligns less well with the traditional content standards that are developmentally appropriate for the elementary-aged participants who make up the majority of afterschool programs. The revision of the National Assessment of Educational Progress (NAEP), anticipated to be ready in 2009, is moving the national test toward a stronger emphasis on the nature of science. State assessments will likely follow the NAEP, but there will be a time lag, and schools will be constrained from changing because they will still be accountable to the old emphases. Afterschool programs can help students prepare, with experiences that are particularly suited to the informal setting.

Working with educational researchers, afterschool programs, and afterschool support networks to develop inquiry instructional models that build on the strengths of afterschool leaders and settings is a promising option worth greater exploration. Inquiry learning experiences have the potential to prepare participants for the new assessments, increase their capacity to do science, and make use of NASA's greatest assets as a content provider and a direct connection to the excitement of exploration and scientific discovery.

Identify foundational concepts that provide a context and support for understanding new NASA missions. NASA's missions do not fit automatically into the science standards scope and sequence. They often deal with content and questions that go well beyond what the standards conceived. This challenge confronts all those trying to translate NASA missions into useful educational tools, whether for formal or informal educational settings. NASA should establish a core set of space science, earth science, and engineering concepts and competencies that reflect the trends in research and discovery; and then articulate the link to (and in some cases extension of) the standards. This would save NASA mission and education staff from having to repeat this

process with every new outreach venture, and would allow educators to provide consistent programming into which new missions could be easily slotted.

Capitalize on the open questions that NASA missions investigate and on the process of discovery.   NASA missions are only the start of an investigation. Conveying to young people that science is about questions to which we do not have answers is critically important. NASA missions have the added advantage of generating tremendous excitement, sending back tantalizing images and clues whose interpretation and significance may not yet be understood. NASA mission materials and experiences should use the afterschool setting to promote young people's understanding of the process of scientific investigation as a continuous work in progress, in which they can participate if they persist in STEM.

Recommendation 3: Partner, tap into existing networks, use intermediaries and science-rich institutions.

NASA doesn't have to do it all. There are networks within and outside of NASA that can facilitate and support development, delivery, and dissemination.

Use existing NASA partners, infrastructure, Explorer Institutes and other NASA networks and resources to create systematic pathways to the afterschool arena. NASA has many resources of which the afterschool community is unaware. Similarly, the afterschool community is large and without centralized points of access for NASA missions and program developers seeking to form partnerships or distribute materials. Creating a centralized access point, or choosing an existing structure such as the Explorer Institutes or the broker-facilitator network to connect afterschool programs to NASA education and outreach programs will help to maximize the potential of NASA and afterschool community partnerships.

Use science centers, universities and other science-rich institutions to help afterschool programs interpret and use NASA content, facilities, and people effectively, and make the cutting edge science accessible to a lay audience. Informal science institutions are practiced in relating science to lay audiences through the media, exhibitions, educational materials, and public programs. Science-rich institutions often have partnerships with community-based organizations, and can provide local support for programs implementing new science programming.

Use intermediaries with expertise in curriculum development to adapt existing NASA curriculum and develop new curriculum on NASA content. Curriculum development experts bring unique skill sets that when added to the scientific and educational expertise of scientists and teachers results in stronger curriculum than any of the parties could achieve alone. In developing afterschool curriculum, the participation of a knowledgeable intermediary is particularly crucial, as afterschool leaders often have less experience in developing curriculum, and less scientific background. Intermediaries can help

afterschool leaders and scientists see where the most promising learning opportunities lie. Particular attention should be paid to creating or adapting materials for elementary school-age participants who constitute the bulk of the afterschool audience.

Partner with existing afterschool coordinating organizations, and with local, regional, and national training structures to build capacity among afterschool programs and staff.
Long term arrangements with national and regional afterschool organizations will provide NASA with an ongoing infrastructure to keep its materials in the afterschool pipeline, and take care of the training and support needed to implement its programs.

Recommendation 4: Take a "One NASA" perspective – Look at the entire NASA portfolio for education and workforce development and identify the most appropriate space for afterschool

Consider the afterschool community as one piece of the STEM pipeline.
A young person's learning experience is not contained in a school day. Informal learning experiences can excite and inspire, support for academic achievement, and expand upon school learning experiences. The afterschool community works with participants for extended periods of time, and often provides social and emotional support that can make the difference for a young person pursuing a STEM career.

Use the engagement, capacity, continuity model as a tool for planning, managing, and assessing NASA's educational portfolio. NASA's primary goal for its support of education is to build the STEM workforce and a science literate, engaged, supportive public, goals not met through individual programs, but through a continuum of experiences.   Jolly, Campbell, and Perlman's (2004) engagement, capacity, and continuity model provides a tool for understanding how programs need to be planned, managed, and assessed in order to reach those goals. Afterschool programming should be considered a piece of the overall pipeline, along with formal education and other science learning in informal settings.

Continue to learn about the goals and needs of the afterschool community.
Educate NASA staff about the afterschool community. Build in regular opportunities to listen and learn from the afterschool community, its participants, the research base, and on-going reform efforts,   Capitalize on NASA's customer focus to respond to the needs and potential of the afterschool arena, and communicate and publicize the role that afterschool programs can play in reaching NASA's educational goals.

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Appendix A: Project Methodology

Scan of the Field Methodology

The scan's central questions were explored through three primary tasks.
1. A review of goals and program design elements for NASA and NSF funded programs serving children and youth in age range 5-18.
2. A scan of topics and age ranges covered in available curriculum resources.
3. A detailed look at NASA curriculum resources.

The scan of the field includes 81 NASA-sponsored and 49 NSF-funded programs, targeting 5-18 year old participants. While our primary interest is in out-of-school settings, we included all projects that directly served K-12 students (as opposed to professional development programs for their instructors) including those targeting in-school audiences. All information collected was in the public domain, provided by the programs or funding agencies on the internet or in publications.

The NASA programs were identified on the education web pages for each science and technology (S&T) enterprise (at the time of the survey, there were five S&T enterprises: Space Science, Earth Science, Space Flight, Aerospace Technology, and Biological and Physical Research), education web pages for each of the nine NASA field centers, and the Space Grant Consortium web pages from each of the 50 states and Puerto Rico. All of those programs featured on the web sites that included direct service to young people in grades K-12 for a longer period of time than a single day or afternoon were included in the scan of the field

In a database, we collected information on the provider, target audience, location, program goals, program structure/pedagogy, number of participants, stated links to national educational standards, and any program elements intended to address underrepresentation. We took text directly from program websites or other materials wherever possible, clearly marking anything we summarized ourselves. In the absence of labeled goal statements or intended program outcomes, we labeled direct statements about what the participants would do and/or learn as goals of the program. We looked at the level of science background and preparation the activities required, the role of the facilitator/teacher, duration and intensity, and at any evaluation data the program collected, in the relatively few instances where that was available.

One hundred forty NASA curriculum resources, analyzed in greater detail, were identified and downloaded. The scan did not include every available NASA curriculum; however, the process of selecting from each S&T enterprise and field center website resulted in a representative cross section of recently

developed materials.

The NSF programs, active in fiscal years 2003 and 2004, were funded through the "youth and community" area of the Informal Science Education Program (ISE), within the Elementary, Secondary, and Informal Education Division (ESIE) of the Education and Human Resources Directorate. The National Foundation's experience dates to the establishment of its Informal Science Education (ISE) Division in 1983. ISE has been the primary supporter of science in community-based and youth organizations; it too sees the potential of the burgeoning afterschool setting and has funded two national conferences that have brought together policymakers, including NASA, with the afterschool community, the informal science community, and intermediary educational development agencies that have longstanding experience in designing curricula, programs, and change efforts. The NSF, charged with promoting the health of science, responds to a congressional mandate to remedy underrepresentation, and one of its two criteria for awarding funding requires that proposers identify how they will have broader impact and address the participation issues. NSF programs were included in the scan of the field to be representative of programs offered by science museums, universities, and other institutions with access to science content and scientists. For the NSF programs included, we worked directly from the award information publicly available on the NSF website, consisting primarily of an abstract written by the awardees.

The first round of analysis took place as the data were collected. A database was designed to catalog information about NASA programs and curriculum. We mapped programs goals and entered descriptions, and looked for information about how participants engage in scientific questions, what background and preparation program instructors needed, and what equity considerations were included in program design.   The database allowed us to conduct some simple quantitative analysis about the number of programs and curriculum targeted at specific age groups, or centered on specific content topics.

Output from our database of NASA programs and abstracts from NSF programs were analyzed using the qualitative data analysis software package, Atlas TI. We identified and coded categories in program and curriculum descriptions that related to program goals, elements of program design, and strategies for reaching underserved audiences. The analysis software allowed us to search and map patterns in the data, and reorganize codes and categories as patterns emerged. In none of this analysis or organization, however, did we make judgments of quality or assume an evaluative role with respect to effectiveness.

Methodology for the Demonstration Site Component

The primary objective for the demonstration project was to explore what was possible in afterschool settings. To reflect the diversity of the afterschool community, we selected three different configurations of afterschool programs

to participate in the study. Configurations selected included afterschool programs operated by 1) an independent community-based organization, 2) a public school, and 3) a local affiliate of a national youth-serving organization. Programs were also selected based on their previous and/or existing relationships with AMNH and their willingness to integrate science into program offerings. A total of six sites serving 240 students participated in the demonstration program. The program staff at these locations included leaders with diverse experiences and educational levels.

Table: Demonstration Site Profiles

	Independent CBO	School/CBO collaboration	National youth serving organization local affiliate
Description	Organization dedicated to revitalization of neighborhood Operates afterschool programs at multiple sites focusing on building literacy skills Demonstration project worked with one site	School and CBO partnered with support from a regional intermediary. School provides the academic portion of afterschool program — math skill building for students in need of remediation.	Local affiliate operates eight sites. Each site offers educational and recreational activities. Demonstration project worked with program providing academic support for underperforming students.
Age of participants	6-10 years old	8-11 years old	6-12 years old
Afterschool leader background	Leaders were high school students, provided with 6 weeks of intensive youth development and literacy training.	Leaders were credentialed teachers.	Leaders were site education directors and part-time staff. Organization requires all education staff to pass a minimum competency test.
Program location and population served	Brooklyn, participants predominately Latino	Bronx, predominantly Latino and African-American participants	Five sites in Bronx, Brooklyn, and Queens — population predominantly Latino and African-American

Each of the sites was provided with a packet of curriculum activities centered on one of two themes, "Astrobiology" or "The Sun as a Star." The packets were composed of activities originally produced by either NASA or AMNH for use in formal classrooms, and often for middle school students. These activities were revised and adapted for elementary learners and for the afterschool setting. For more about the specific activities used and adaptations made, see the related prototype curriculum packets also produced by this project.

In addition to hands-on and discussion-based learning activities, embedded data collection activities were included in each packet of activities. These provided opportunities for participants to articulate their thinking and for leaders to capture that thinking to share with the research team.

Leaders at each of the sites were provided with training. The length of the training session depended upon the time available to the leaders. The independent CBO was able to dedicate ten hours to training before the leaders began school for the year, split between AMNH and their own site. The school-based program dedicated one professional development day to training at AMNH. The national organization affiliate brought individual sites online at different start dates. Two to three hours of training, provided on site before participants arrived during the week or four to five hours on a Saturday was the norm for these sites.

We collected several forms of qualitative data in partnership with afterschool leaders and participants. Student participation in data collection was built into the activities. We created instruments for leaders to record their impressions of activities. Focus groups and interviews with participants and leaders were conducted at the public school, the community-based organization and two sites of the national organization. Additionally, AMNH researchers made multiple observations at each of the sites. The following provides more details on the data collection methods we used.

Participant data collection. Participants were given science journals to record their experiences throughout the project. Built into the curriculum were activities that allowed the participants to give us information about what they had learned and enjoyed.

Site-leader data collection. Session summary sheets were provided to leaders as a place to record insights about what the participants had just experienced in a session. On the instructions for each activity, places were included to record feedback on the design of activities, any adjustments/revisions leaders made, and the actual amount of time the activity took.

Site-leader data collection. Session summary sheets were provided to leaders as a place to record insights about what the participants had just experienced in a session. On the instructions for each activity, places were included to record feedback on the design of activities, any adjustments/revisions leaders made, and the actual amount of time the activity took.

Focus groups/interviews. Focus group discussions and interviews of both participants and leaders were conducted. Discussions were held in an open-ended question format, with one AMNH researcher facilitating the discussion and another recording participant feedback through written notes. Focus

group sessions provided feedback on the activities. They were designed to elicit reflections about the activities, what they enjoyed and found engaging, what confused them and what was clear, what worked well and what might have been done differently.

Site observations*.* AMNH researchers observed all program sites at least once. These observations helped us to understand how the curriculum was being implemented and also provided immediate feedback from leaders. Researchers wrote extensive field notes during observations.

Data were compiled and analyzed using ethnographic analysis software. Emerging themes and counter examples were identified and serve as the basis for the findings that are presented in the report.

Appendix B: Scan of the Field Program Matrix

	Activity-Based	Project-Based	Mentor/Internship
Youth workers and other adults lead	**Space-Themed Activities:** Activities intended to engage, excite, introduce topic for fun, rather than concept mastery. *Leader Role:* Model and facilitate activities. *Support Structure:* Provides activities *Target Age:* elementary	**Data collection projects:** Participants learn and execute data collection protocols and contribute data to ongoing professional science investigation. *Leader Role:* Train participants in protocols, oversee collection and submission of data. *Support structure:* Provides protocols for collection/submission of data, training for instructors. *Target Age:* All ages	
	Curriculum-Based: Activities part of a self-contained curriculum, learning goals related to content mastery. *Leader Role:* Lead learning activities. *Support Structure:* Provides curriculum and training, support for instructors. *Target Age:* Elementary & middle school	**Design competitions:** Project focused on designing something to solve problem, perform task *Leader Role:* Familiarize group with guidelines, facilitate group work, connect group to technical advisor. *Support Structure:* Provides challenge, guidelines, leader materials, judges competitions. *Target Age:* All ages	
Educators with science backgrounds lead…..	**Career-focused course**: Activities centered on exposing participants to college and/or STEM careers *Leader Role*: Design curriculum, lead learning activities, set up tours & career talks. *Support Structure:* Selects participants, designs overall program layout, supports instructors. *Target Age:* Middle and high school students	**Participant driven research:** Participants engage in their own scientific investigation, either by group leaders or designed individually. These programs provide access to professional scientific equipment or data (telescopes, databases, etc). *Leader Role:* Designs project using the relevant science resource or guides participants in designing their own research. *Support Structure:* Provides training for instructors on the scientific resources and the kinds of research projects that can be conducted with those resources. *Target age:* Middle, high school	**Teacher/Scientist Partnerships** STEM professional is partnered with a teacher, makes visits to class. *Leader role:* Jointly design learning activities with partner scientist, schedule and plan scientist visits to class, carry out lessons preparing students for scientist visits. *Support Structure:* Pairs scientists with teachers, provides guidelines for commitment, in some cases provides collection of learning activities. *Target Age:* Elementary, middle school
	Role Playing/Mission Simulation: Participants take part in simulation of space mission, career, or science-based mystery. Concepts are interdisciplinary and connected through context of situation. *Leader Role:* Conduct group learning activities, facilitate role playing. *Support Structure:* Design activities, provide specialized equipment/facilities. *Target Age:* Elementary, middle school		
STEM Professionals lead….	*STEM professionals serve either as advisors for curriculum developed for activity-based programs or as guest speakers/instructors.*	*STEM professionals serve as advisors for individual teams participating in design competitions*	**Internship or One-to-One Mentoring:** Participants work in professional STEM setting and/or are paired with STEM professional serving as mentor *Leader Role:* Mentor *Support structure:* Selects participants, makes job assignments, provides training *Target Age:* High school, college

One of the most important factors in designing science educational programs is the experience and background of the primary adult leader. Understanding who is available to lead, the support they will need, and the program design best suited to their strengths should be a central guiding factor in program design. The scan of the field identified three major categories of programs: activity-based, project-based, and mentor/internships. Each of those categories contained sub-variations based primarily on the background of the adult leader working most directly with the participants in each program. The matrix above captures these variations.

Programs Included in the Scan of the Field

A complete listing of all the programs included in the scan of the field follows. The NASA programs include all programs that involved some form of direct service to young people in grades K-12 identified on the websites of the five science and technology enterprises, each of nine NASA field centers, and the space grant websites for each of the fifty states and Puerto Rico in 2003. The NSF programs are those active in fiscal year 2004, funded by the Informal Science Education division, youth and community program category.

NASA-funded Programs

Table Key: A= activity-based P= project-based M/I = mentor/internship

Program	Managing Institution	A	P	M/I
2003 Flight Forecast Competition	US Centennial of Flight Team		X	
Access Earth	University of Southern Maine		X	X
Aeronautics and Earth Science Academy	Medgar Evars College	X		
Aim High Space Camp	Delaware Space Grant	X		
Alaskan Student Rocket Project	University of Alaska Fairbanks		X	
Amateur Radio on the International Space Station	Johnson Space Center and Goddard Space Flight Center		X	
Ames Aerospace Encounter	NASA Ames Research Center	X		
Apprenticeship Program	Goddard Space Flight Center			X
Astronomy Camp	University of Arizona	X	X	
Aviation Careers Education Academy	Aviation Institute, University of Nebraska	X		
Biotechnology for Kids	Alabama Space Grant, University of California Irvine		X	
Buckeye Women in Science, Engineering, and Research (B-WISER)	Ohio Space Grant, College of Wooster	X	X	
Chesapeake Bay Watershed Initiative	Maryland Space Grant		X	
Coyle Afterschool Tutoring Program	Langston University			
Dark Skies, Bright Minds	Badlands Observatory		X	
Delaware Aerospace Academy	Delaware Aerospace Education Foundation	X		
Digital Learning Network	Johnson Space Center			
Dropping in a Microgravity Environment	Glenn Research Center		X	
Earth to Orbit Engineering Design Challenge	Marshall Space Flight Center, Dryden Space Flight Center		X	
Engineering Your Future	Carnegie Mellon	X		
Entry Point	NASA, NSF, IBM, JP Morgan Chase, Texan Instruments			X

Program	Managing Institution	A	P	M/I
Forest Watch	University of New Hampshire		X	
Future Flight Hawai'i	Hawaii Space Grant	X		
Gaia Crossroads Project	Bigelow Laboratory for the Ocean Sciences		X	
Girl Scout Aerospace Badge Camp	University of Nebraska	X		
Girls' Adentures in Mathematics, Engineering, and Science	University of Illinois, Urbana			X
The GLOBE Program	University Corporation for Atmospheric Research/ Colorado State University		X	
Goldstone Apple Valley Radio Telescope Program	NASA, Jet Propulsion Laboratory, Lewis Center for Educational Research		X	
Graphic Visualization Intern Program	Goddard Space Flight Center			X
High School Aerospace Scholar Program	Johnson Space Center			X
High School/High Tech	Antelope Valley High School and Dryden Space Flight Center			X
Idaho GEMS	University of Idaho College of Engineering	X		
Illinois Aerospace Institute	University of Illinois, Urbana	X		
Improving Literacy in Science & Technology: 4-H Aerospace	4-H Extension Program		X	
INSPIRE Project	Goddard Space Flight Center, Chaffey High School, Ontario, CA		X	
Institute on Climates and Planets	Goddard Space Science Institute			X
ISS Earth KAM	UC San Diego, NASA, TERC		X	
Job Shadowing Program	Goddard Space Flight Center			X
Johnson Space Center Day Camps	Johnson Space Center	X		
LA's BEST	Jet Propulsion Laboratory, City of Los Angeles, Los Angeles Unified School District	X		
Launching a Dream	Delaware Aerospace Education Foundation	X	X	
Mars Settlement Design Competition	White Sands Testing Facility, Johnson Space Center		X	
Math Counts	Math Counts Foundation		X	
Mentor/Mentee Program	Goddard Space Flight Center			X
Mission to Mars Camp	Penn State Fayette	X	X	
Mobile Math Circle	University of Southern Alabama	X		X
NASA Student Involvement Program	Institute for Global Environment Studies, TERC		X	
Native Americans in Marine and Space Science	College of Oceanic and Atmospheric Science at Oregon State University			X
Nittany Science Camp for Girls	Penn State		X	
Odyssey of the Mind/NASA partnership	Goddard Space Flight Center		X	
Office Education Program	Johnson Space Center, Kennedy Space Flight Center			X
Personal Satellite Assistant Challenge	Ames Research Center		X	
Project ASTRO	Astronomical Society of the Pacific	X		X
Project SMART	University of New Hampshire		X	
Project STEP (Scientist & Teacher Education Program)	Illinois Space Grant			X
Research Paper Contest for Macon County Students	Alabama Space Grant, Tuskegee Univeristy		X	
Robotics Education Project	Ames Research Center		X	
Saturday Academy	Oregon State University			X
Science Advisor Program	White Sands Test Facility, New Mexico State, Dona Ana Community College, White Sands Missile Range. Johnson Space Center has a similar program in Houston area			X
Science and Mathematics	Oregon State University		X	X

Program	Managing Institution	A	P	M/I
Investigative Learning Experiences (SMILE)				
Science en Espanol	Rhode Island Space Grant			X
Space Camp	US Space and Rocket Center, Huntsville, Alabama	X		
Space Experiment Module	Space Shuttle Program		X	
Stargazer	Northern Arizona Univeristy, Arizona Space Grant		X	X
Structured Intern Program	Goddard Space Flight Center			X
Student Temporary Employment Program	Ames Research Center			X
Student's Online Atmospheric Research (SOLAR)	Stratospheric Aerosol and Gas Experiment III (SAGE III)		X	
Summer High School Apprenticeship Research Program (SHARP)	NASA Centers			X
Telescopes in Education	Mt. Wilson Institute		X	
The Great Moonbuggy Race	Marshall Spaceflight Center		X	
The Making of Scientists & Engineers	University of Denver	X		X
Tupelo Middle School Mermaids	Space Grant mini-grant	X		
Visiting Student Enrichment Program	Goddard Space Flight Center			X
Worldwide Youth in Science and Engineering (WYSE)	University of Illinois, Urbana			X
You be the Scientist	Elizabeth City State University		X	
Total		20	36	26

NSF-funded Programs

Table Key: A= activity-based P= project-based M/I = mentor/internship

Program	Managing Institution	A	P	M/I
123 Ready Set Go! Math for Younger Children and Families	Minnesota Childrens Museum	X		
After-school Adventures in Wildlife Science (ASCEND)	Wildlife Conservation Society	X	X	
After School Science Adventures	Great Lakes Museum of Science, Environment, and Technology	X	X	
After-School Math PLUS	Educational Equity Concepts	X		
After School Program Exploring Science (APEX)	Miami Museum of Science	X		
American Museum of Natural History ASCEND Program	American Museum of Natural History	X	X	X
An Intergenerational Program in Science, Mathematics, and Technology	SPRY (Setting Priorities for Retirement) Foundation	X		
Archeology Pathways for Native Learners	Mashantucket Pequot Museum and Research Center		X	
Birds in the 'Hood/Aves del Barrio	Cornell University		X	
Bringing CoCoRaHS to the Central Great Plains: An Informal Science Education Project	Colorado State University		X	
Building Math Momentum in Science Centers	TERC	X		
Coastal Communities for Science: A Bearing Sea Partnership	World Wildlife Fund, United States		X	
Designing Youth: Teens Engaging Children in Design Engineering	St. Louis Science Center	X		
Engagement in Learning	Texas Agriculture Experiment Station	X		

Program	Managing Institution	A	P	M/I
Exciting Girls, Minorities, and Rural Youth About Engineering	Ohio State University Research University	X		
Explore It! Science Investigations in Out of School Programs	Education Development Center	X		
Families Exploring Science Together	New Jersey Academy for Aquatic Science	X		
Family ASTRO	Astronomical Society of the Pacific			X
Forging Partnerships with Libraries: Explore! and Fun with Science!	University Space Research Association	X		
Galaxy Explorers: An Intensive After School Science Enrichment Internship Program	Chabot Science Center			X
Garden Mosaics	Cornell University		X	
Hands on Optics: Making an Impact with Light	SPIE – International Society for Optical Engineering	X		
Home, School, & Community: After School Math for Grades 3-5	Developmental Studies Center	X		
Imperial Valley Agriculture Learning Center	El Centro School District	X		
Investigations in Cell Biology	Science Museum of Minnesota		X	
Kinetic City After School: An On-line Adventure	American Association for the Advancement of Science	X		
Master Science Educators	Oregon State University		X	
Math Packs for Families	TERC	X		
Milwaukee Public Museum "Science Explorations" After School Program	Milwaukee Public Museum	X	X	X
Mission Discovery	Carnegie Institute	X		
Mixing in Math: Transforming the Role of Math in Afterschool	TERC	X		
Monarch Butterfly Larval Monitoring: Nationwide Citizen Science Initiative	University of Minnesota, Twin Cities		X	
Mother Goose Cares About Math and Science	Vermont Center for the Book	X		
National Invasive Species Monitoring: A Citizen Science Project	Chicago Botanic Garden		X	
Newburg ASCEND	Newburg City School District	X	X	
Northwest Corps of Rediscovery	Portland State University		X	
Parent Partners in School Science PPSS	Franklin Institute Science Museum	X		
PEERS (PACTS Environmental Education, Research, & Service)	Franklin Institute Science Museum	X	X	
PIE Network: Promoting Science Inquiry and Engineering	Massachusetts Institute of Technology		X	
Planning Grant for "Imagine That" Explorations in Science, Technology, and Engineering for Students & Families	Chabot Science Center	X		
Planning for STEM Education Reform in Greater Mohawk Valley	Utica College		X	
Project Butterfly WINGS: Winning Investigative Networks	University of Florida		X	
Project Science Unveils Mysteries (Project SUM)	African American Male Achievers Network	X		
QCC Tech ASCEND	CUNY Queensborough Community College	X		
Science & Everyday Experiences (SEE) Initiative	Delta Research & Educational Foundation	X		
Science Education Resource Center	Morehouse School of Medicine	X		
Science Quest	Education Development Center		X	
Science Technology Education Program (STEP) Up for Youth	California State University, Los Angeles	X		

Program	Managing Institution	A	P	M/I
SEEK: Science & Engineering Experiences for Knowledge – An ASCEND Project	University of Florida	X	X	
Sisters in Science	Temple University	X	X	
Teens Exploring and Explaining Nature and Science (TEENS)	Chicago Academy of Science	X		
Thinking SMART	Girls Incorporated	X		
UMass Lowell Design Camp After School	University of Massachusetts, Lowell		X	
UPCLOSE	COSI Toldeo	X		
Urban Ecology Field Study Program	Boston College		X	X
Urban Math & Science Student Service Corp	Fresno Unified School District			X
Whitney M. Young Scholars in Science (WYSci)	Louisville Science Center	X		
Wonderwise 4-H	University of Nebraska, Lincoln	X		
Worcester Pipeline Collaborative ASCEND Initiative	University of Massachusetts Medical School	X	X	
Total		34	25	6

Appendix C: Curriculum included in the scan of the field

This table lists all of the NASA curricula included in the scan of the field. Curricula were identified through the Earth Science Education Catalog, The Office of Space Science Online Resources, NASA Center web sites, Space Grant web sites, and other locations (other S&T enterprises, pages for direct service programs also included in the scan of the field). Curricula included activities intended to be used in classroom or other group learning situations.

Table: Curricula included in the scan of the field

S= Specific reference to National Science Education Standards (NRC, 1996) and/or Benchmarks for Science Literacy (AAAS, 1993)

Title	K-2	3-5	6-8	9-12	S
Earth Science Education Catalog					
Antarctic Expeditions: Ozone Hole			X		X
At Work in the Ocean				X	X
CEOS Resources in Earth Observation				X	
DataSlate			X	X	
Discover Earth Classroom Materials			X	X	X
Earth Observatory		X	X	X	X
Even-Based Science Remote Sensing Activities			X		X
Exploring the Environment	X	X	X	X	X
Finding Impact Craters with Landsat			X		X
From a Distance: An Introduction to Remote Sensing GIS/GPS	X	X	X	X	X
Gaia Crossroads Project	X	X	X	X	
Global Systems Science				X	X
GLOBE Program	X	X	X	X	X
How Can We Grow Smarter?					
Into the Arctic: Information and Education Activities for Studying Climate				X	
Investigating the Climate System: NASA's Tropical Rainfall Measuring Mission			X	X	X
ISS Earth KAM			X		X
Mission Geography	X	X	X	X	X
NASA Sci Files					X
NASAexplorers: Online Lessons and Resources	X	X	X	X	X
Ocean World			X	X	X
Pacific Expeditions: El Nino			X	X	X
River Expeditions: The Amazon			X	X	X
S'Cool: Students' Couble Observations Online	X	X	X	X	X
Signals of Spring			X	X	X
SkyMath: Mathematics for a Blue Planet			X		X
Speaking in Phases					
Students' Online Atmospheric Research (SOLAR)	X	X	X	X	X
Studying Earth's Environment from Space				X	X
The Adventures of Amelia the Pigeon	X	X			X
The Adventures of Echo the Bat	X	X			X
The JASON Project		X	X		X
The Potential Consequences of Climate Variability and Change	X	X	X	X	X
The WorldWatcher Project			X	X	X
Understanding the Biosphere from the Top Down		X	X	X	X
Visit an Ocean Planet			X	X	X

AMERICAN MUSEUM ᴏꜰ NATURAL HISTORY

Title	K-2	3-5	6-8	9-12	S
NASA Center Web Page					
Air is Something	X	X			X
All Star Network			X	X	X
Build Your Own Wind Tunnel				X	
Convection Activities		X			X
Digital Learning Network	X	X	X	X	X
Explore!		X	X		
Imagine Mars	X	X	X	X	X
Microgravity			X	X	X
NASA Quest		X	X	X	X
Near Earth Achievable Remote Sensing	X	X	X	X	
Practical Uses of Math and Science	X	X	X	X	X
Rock-It Science	X	X	X		X
Young Features on Europa					X
Office of Space Science					
Active Astronomy				X	X
Anatomy of Black Holes				X	
Astrobiology in Your Classroom: Life on Earth … and elsewhere?			X	X	X
Astrocapella			X	X	X
Astroventure			X		X
At home Astronomy	X	X	X		
Blinded by the Light		X	X	X	
Can a Spacecraft use Solar Panels at Saturn?			X	X	X
Can Photosynthesis Occur at Saturn			X		X
Catch a Gravitational Wave, Dude!					
Cosmic Chemistry: An Elemental Question				X	X
Cosmic Chemistry: Comogony			X	X	X
Cosmic Chemistry: Planetary Diversity			X	X	X
Cosmic Chemistry: The Sun and Solar Wind			X	X	X
Cosmic Survey: What are Your Ideas About the Universe			X	X	
Destination Mars			X	X	
De-twinkle Little Stars		X	X	X	
Drawing a Scale Model of the Solar System			X		
Dynamic Design: A Collection Process			X	X	X
Everyday Classroom Tools	X	X			
Excavating Cratering			X	X	X
Exploring Mars		X	X	X	X
Exploring Meteorite Mysteries			X	X	X
Exploring Origins	X	X	X	X	X
Exploring Planets in the Classroom	X	X	X	X	X
Exploring the Earth's Magnetic Fields	X	X	X	X	X
Exploring the Moon			X	X	X
Finding Worlds That Look Like Stars	X	X	X		X
Gamma Ray Bursts				X	X
Gingerbread Spacecraft	X	X			X
Gravity Probe B: Examining Einstein's Space-time with Gyroscopes			X	X	
Heat: An Agent of Change			X	X	X
How astronomers use spectra to learn about the sun and other stars		X	X	X	X
In a Different Light			X	X	X
Lightning in a Planetary Atmosphere			X	X	X
Mapping Worlds That Look Like Stars	X	X	X		X
Mars Activities	X	X	X	X	
Mars Exploration: Is there water on Mars?			X	X	X
Mars Exploration: The Great Martian Flood and the Pathfinder Landing		X	X	X	X

Title	K-2	3-5	6-8	9-12	S
Site					
Mars Student Imaging Project	X	X	X	X	X
Messenger Education Module: Unit 1: Staying Cool	X	X	X	X	X
Monitoring the Sun's Corona			X	X	X
Navigating by Good Gyrations			X	X	
Newton's First Law				X	
Newton's Law of Gravitation				X	
Newton's Second Law of Motion				X	
Newton's Third Law				X	
Northern Lights and Solar Sprites	X	X			X
Observing the Outer Planets			X	X	X
Packing for a Long Trip to Mars			X		
Planet Quest			X	X	X
Planetary Billiards		X	X	X	X
Planetary Magnetic Fields		X	X	X	X
Sand or Rock: Finding out from 1000 km			X	X	X
Saturn Educator's Guide			X		X
Scaling the Spectrum				X	
Scattering: Seeing the Microscopic Among the Giants			X	X	X
Solar Storms and You			X		X
Spin and Spectrum			X	X	X
Stardust			X		X
Taking Apart the Light					
The Grand Canyon of Mars and How it Formed			X	X	
The Life Cycle of Stars				X	X
The Northern Lights			X		
The Spinning World of Spacecraft Reaction Wheels			X	X	X
Tidy Up Those Sloppy Force Fields			X	X	
Unveiling Titan's Surface			X	X	X
Venus: A Global Greenhouse			X	X	X
Waves and Interference		X	X	X	X
Waves Light Up the Universe	X	X	X	X	X
What is Synchronous Rotation?	X	X	X	X	X
When the Sky is Falling			X	X	X
Which Way Should I Point?	X	X	X	X	
Who's Got the Power?: Exploring Sicnece and Math Skills of Cosmic Magnitude				X	X
Space Grant					
CASDE (Consortium for the Application of Space Data for Digital Earth)	X	X	X	X	X
Citizen-Explorer Satellite	X	X	X	X	X
Exploring Planets in the Classroom	X	X	X	X	X
Space Explorers		X	X	X	
Other					
Aeronautics Kid's Page	X	X	X		X
Aeronautics Learning Laboratory for Science Technology (ALLSTAR)			X	X	X
Differential Rotation of the Sun				X	X
Flight Testing Newton's Laws				X	X
Human Physiology in Space				X	
ICP: What Determines a Planet's Climate				X	X
Kids as Airborne Mission Scientists (KAMS)			X		X
Living with a Star: Teacher Resources for Understanding Connections between the Sun and Earth	X	X	X	X	X
Re-living the Wright Way	X	X	X	X	X

Title	K-2	3-5	6-8	9-12	S
Space Agriculture in the Classroom		X	X	X	
Stanford Solar Center Activities		X	X	X	X
Sun in Time			X		X
Virtual Skies				X	
Totals:	*38*	*54*	*110*	*106*	*94*

Appendix D: Afterschool Programs and Science: What's Next?

During the development of *NASA and Afterschool Programs: Connecting to the Future,* the AMNH project staff, in order to gain a variety of perspectives, brought together panels of experts to discuss the integration of science instruction into afterschool programming. Some of these experts and their colleagues have drawn upon their expertise and points of view in this collection of essays, expanding upon the themes and questions discussed in this report.

Trends in Afterschool Education

Where is Afterschool Headed and How Do Science Learning Opportunities Fit into the Afterschool Landscape? Lucy N. Friedman, The After-School Corporation (TASC)

Thoughts on Content Choices for NASA and Afterschool

What NASA Has to Offer, David Hammer and Janet Coffey, University of Maryland
Education Standards, Achievement, and the Afterschool Program, Jacinta Behne, John Ristvey, Deb Aruca, and Judy Counley of Mid-continent Research for Education and Learning (McREL)
The Revolution in Earth and Space Science Education, Daniel Barstow, TERC
Trends in Science Education, Richard Duschl, Rutgers University

Thoughts on Afterschool Curriculum and Instruction Needs

Afterschool Program Staff and Science Instruction: What We Bring to the Table, Emilio de Torre, Madison Square Boys and Girls Club
Are We Alone? Transforming "Astrobiology" for Use in Afterschool Programs, Daniel Barstow, TERC
Our Wish List: What we Would Like to see in a NASA Afterschool Program, Tom Bromage, Felicia Cherry, Jessica Diaz, Adam Liebowitz, Arlene Mbonu, and Jacqueline Torres, afterschool instructors participating in the *Connecting to the Future* demonstration sites
From Products to Programs: Telling Stories with NASA Educational Materials, Rachel Connolly and Minna Palaquibay, American Museum of Natural History

How NASA and Afterschool Community Collaboration Might Happen

Reaching Out: A Call for Community Engagement, Dishon Mills, Boston Public Schools, After-school Programs

How can NASA Work With,Listen to, and Learn From Existing Afterschool Networks?, Shari Asplund, Co-chair of the Science Mission Directorate's Community-Based Organizations Working Group

The NASA-GSUSA Collaboration: Together We Inspire Young Women to Explore, Discover, Understand, Leslie Lowes, Rosalie Betrue, Jaclyn Allen, Kay Tobola, and Michelle Hailey

Where is Afterschool Headed and How do Science Learning Opportunities Fit Into the Afterschool Landscape?

Lucy N. Friedman, President, The After-School Corporation (TASC)

Introduction

> *"After-school programs can respond to children's interests and concerns, giving children a measure of control…putting children in active roles as learners…After-school programs provide developmental experiences that schools lack time for, and that low-and moderate-income families may lack resources to purchase. These include, of course, the visual and performing arts, humanities, civics, physical activities and sports. One might argue that, given declining attention to them in school, the natural sciences have to be added to this list."* (Halpern, 2004, Confronting "The Big Lie": The Need to Reframe Expectations of After-School Programs, p. 16)

In fact, afterschool provides an ideal setting for unlocking the potential scientist in every student and reinforcing the science education received during school hours. Compared to the school day, the smaller groups, the longer time slots, and the less formal environment of most after- school programs provide opportunities for children to visit museums, study neighborhood environmental conditions, and perform laboratory experiments. Seventy-five percent of Nobel Prize winners in science echo this sentiment, stating that their passion for science was first cultivated in non-school environments.

Evolution of the Afterschool Movement

Although afterschool education is hardly a new concept, the notion that quality, comprehensive enrichment opportunities should be universally available and sustained with public resources is a relatively recent aspiration. In the past, a family's socio-economic status too often determined their level of access to afterschool services. Children from low-income families often had to care for younger siblings, were left to their own devices, or, in some communities, attended recreation programs. In comparison, children from affluent communities were more likely to spend their time after school attending dance, karate, college prep, and photography classes. Recognition of this disparity, and its effects on the nation's widening achievement gap, combined with the fact that most parents were now working outside the home, provided the impetus for a new movement. The movement advocates that publicly funded, quality afterschool opportunities to be made available to all children, regardless of class, race, religion, or geographical location.

Moreover, while the information children are required to master grew exponentially beginning in the 1960's, the school calendar remained essentially the same from the 19th century onwards. It is not surprising then that educators

have become more interested in using afterschool time to deliver, or at leastreinforce, some elements of the academic curriculum. Ironically, the time allocated to the sciences, which contributed significantly to this knowledge explosion, has declined in many schools, in favor of greater focus on the acquisition of literacy and numeric skills.

Where is the Afterschool Field Headed?

The afterschool movement is now entering the new developmental phase: it is becoming a "field." As the number and variety of supporters of afterschool programming has grown, a consensus is growing among children, parents, youth workers, educators, social service experts, and community leaders about what makes a quality afterschool program.

This blueprint for the coming decade draws upon the experiences, practices, and values of traditional providers such as: the YMCA; Boys and Girls Clubs; Girls, Inc; civic and church groups; sport leagues; park recreation programs; and libraries. It calls for a balanced program that offers a mix and choice of programming, includingacademics, arts, sports, and community service,in a nurturing environment where there are opportunities for children to connect to each other and adults, and to be exposed to new experiences. At the same time, afterschool providers will most likely be tackling the following issues:

> **Identifying Strategies to Increase Participation Rates**.
> Research has consistently confirmed the obvious; that "higher levels of attendance in out-of-school-time (OST) programs have been significantly correlated to scholastic achievement, higher school attendance, more time spent on homework and on positive extracurricular activities, enjoyment and effort in school, and better teacher reports of student behavior" (Harvard Family Research Project, Issues and Opportunities in Out-of-School Time Evaluation Brief, July 2004). Despite these findings, many programs have neither expected nor achieved high attendance rates. Increasingly, though, program operators are taking on this challenge by redesigning programs and policies to encourage better attendance. For example, New York City is planning to tie funding for OST programs to participation rates. Strategies from the field which increase participation include: offering more choice of activities for participants, providing more engaging, hands-on activities, and making more group projects available so that children feel a commitment to their peers.

> **Developing Program Models for High School Students That Support Their Transition Into Adulthood.** Along with the increased attention on America's high schools has come a greater interest in the quality of afterschool programs for this age group. Attracting teens is a challenge, because their interests are more varied and their attendance in school more variable. Even

engaged youth have competing activities such as earning money, taking care of younger siblings, or just "hanging out." Using an apprenticeship model, Gallery 37/After School Matters in Chicago has developed one successful approach, but in the coming years we will need more. Science projects in afterschool give high school students opportunities to focus on job training, career exploration, and college prep. In addition, environmental monitoring projects have shown particular potential for capturing teens' interest in environmental justice issues.

Creating More Curriculum and Professional Development Opportunities for the Afterschool Field. With a move towards aligning afterschool with regular school day learning, more afterschool specific curricula are being developed. KidzMath and KidzLit created by Development Studies Center are two programs that were created for the diverse staff (college students, teachers, artists, volunteers, parents) that works in afterschool programs. Another example is a science textbook that is being adapted for afterschool. This newly createdcurricula will guide the development of staff training.

Offering More Physical Activity. The growing concern about the childhood obesity epidemic, coupled with cuts in physical education from the regular school day, makes afterschool a natural venue for children to exercise and learn about healthy eating. Activities like yoga, table tennis, tai chi, soccer, kickboxing, and other sports have become increasingly popular in afterschool and are often childrens' number one choice of activity. Afterschool science programs provide a natural setting for children in which they can explore their communities, be physically active, and learn more about healthy eating and the importance of life-long fitness.

How Does Science Learning Fit into the New Afterschool Paradigm?

Afterschool programs provide ideal environments for children to engage in scientific inquiry, critical thinking skills, teambuilding, problem solving, and participate in project-based and experiential learning. Science learning meets the need for balance in afterschool programs by integrating math and reading and making real world connections between the theoretical and the observed. In addition,afterschool is particularly appropriate for teaching scientific methods, not just scientific content. Science learning is a perfect fit for afterschool because:

It offers opportunities for stealth learning. In New York City, The Afterschool Corporation (TASC) has found that science learning activities are some of the most popular among students. At one program in the Bronx, students took regular trips to Edgar Allen Poe Park to study wildlife. This project-based learning

experience gave studentsthe chance to get fresh air, exercise, think about the community that they live in, keep nature journals, and discover wildlife they might not normally notice.

Experimentation helps give children the opportunity to learn crucial 21st century skills of teamwork and problem solving. At another program, fourth and fifth graders grew lima beans. In one cup, they planted beans and added water. In the other cup, they planted beans and then added a common household product, such as dish soap, bleach, or cleaning solvent. They then compared the growth, watching the control group flourish and the experimental group wilt and wither. This process led to inquiry with children questioning how plants come to life, the effects of sunlight, water, and regular care, and how they, themselves, could better care for their environment.

Science learning in afterschool can give older children the opportunity to mentor younger children. During a TASC summer program partnership with the American Museum of Natural History (AMNH)--which grew out of the collaboration between NASA and AMNH--high school students were trained to teach lessons on bird life in New York City to elementary school children. One of the most critical lessons learned, according to one high school student, was the development of inquisitive minds. "Kids were more concerned with learning the right questions to ask rather than just searching for the correct answers," the student said. In the Science Mentoring Project(a collaboration among Educational Equity Concepts (EEC), the New York City River Project and a school on Manhattan's Lower East Side) high school mentors conducted an urban ecology project with fifth-graders in the school's afterschool program . Both the younger and older students benefited from these mentoring relationships.

Science learning prepares students for competition in the global economy and helps to meet the needs of businesses. Currently there is a shortage of trained scientists in this country. Thousands of scientists from other countries come here to fill these lucrative jobs. At the same time, scientists and other leaders express concern about the under-representation of people of color within the field. Afterschool programs that serve communities of color, may help to close this gap within the science workforce.

Conclusion

While both the afterschool and science fields are at a crossroads, association with the other enhances the potential for each to flourish. Groups like the Coalition of Science After School, that includes leaders in both science

education and afterschool, are meeting on a regular basis to strategize about how science can be a bigger part of the afterschool hours. With dozens of funding equity lawsuits nationwide demanding a longer school day and more enrichment opportunities in the afterschool hours, science learning has the potential to gain even greater currency. In addition, science will become an indicator of success under the No Child Left Behind Act next year, making afterschool science curriculum and professional training opportunities more necessary and timely.   By infusing science learning into afterschool, we can take the next step in our efforts to level the playing field for children.

We've seen that afterschool not only helps children and working families but entire communities by keeping children safe during the hours of 3:00 p.m. and6:00 p.m. Children who attend afterschool feel more connected to their community, are less likely to get "lost" in the system, and often begin to see themselves as life long learners.

Science learning will better prepare children for competition in the global economy and improve their critical thinking skills. We should encourage them to ask critical questions, support the organic and sometimes non-traditional process of finding the answers. Most of all, we can encourage many, many more of our children to become scientists.

What NASA Has to Offer

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When people think of what NASA has to offer science education, one natural starting place is knowledge: NASA scientists have a lot of it, from basic concepts to new results of NASA missions. Another is motivation: the topics and techniques at NASA could fascinate children, spur them to study science, and maybe to consider it as a career. With missions that focus on everything from black holes, the expanding universe, and comets to the possibilities for human space exploration and extra-terrestrial life; with robotic probes to explore Mars and Titan and the outer reaches of the solar system, human space flight, and orbiting telescopes, NASA is simply a wonderland for science education.

But, as the report discusses, there are serious challenges to using NASA resources. First, the most exciting topics are difficult to study in any but a superficial way without background understanding. If the purpose is knowledge, it just doesn't make sense to spend time on black holes before children have basic understanding of mass and gravity. The exciting topics might be motivation to study basic concepts, but children who were drawn in by the idea of black holes may lose interest as they end up spending most of their time in much more mundane, earth-bound activities.

Second, for many children the first blush of excitement about spacecraft or other planets and distant moons fades quickly as the details of information come in. That's why educators working from NASA content often look to old strategies, designing activities around games (from high tech video to bingo and word-searches), stories and songs (now including rap), and the old stand-by—candy. Maybe that's not a good sign: If the purpose is motivation for science, shouldn't the science do the motivating?

More powerful possibilities

Knowledge and motivation may be the first things that come to mind because of how people think about science education: Learning is about acquiring knowledge (or "constructing" it), and that takes engagement and attention. These seem to be obvious truths, but as science has shown again and again, obvious ideas sometimes get in the way. The pilot work in the afterschool programs described in this report point to further and maybe more powerful ways to think of connections between NASA and science education.

Let's start with what children said they enjoyed: "I liked talking," "I liked saying my opinion," and "You got to say some things that you really wanted to say for a long time," were typical comments made by participants describing this activity. This fits with what we and others have seen working with children (and what parents already know): They like talking. It doesn't take games or candy. Children are motivated by opportunities to express themselves, and all the more

so when they expect someone is genuinely paying attention to and appreciating what they have to say.

More than that, they like talking about many of the same questions near and dear to NASA scientists. But—is this what most people would expect?—they aren't always so interested in finding out the answers scientists have decided are right. They often, as they do in the vignettes, would prefer to think through the questions and talk and argue among themselves.

But what does all that talking do for them? Most of what they're saying is wrong! And if they're not interested in what experts have to say on the matter, what do they need NASA for? We want to offer some answers to those questions, but first it will help us to answer the analogous questions for a more familiar afterschool activity: basketball. For the moment, consider this: if you wander through the labs at Goddard or Ames or Langley and peek in on scientists as they work, you won't find them playing videogames or singing songs (at least not as part of their work!). But you will often find them thinking and talking and arguing.

Basketball

We're stopping to talk about basketball because in some respects "afterschool basketball education" already has what we'll suggest afterschool science education needs. Basketball is another area where children are mainly motivated to do. If you gave small children a basketball, even if they'd never heard of the game they'd probably start bouncing it and throwing it and chasing it around the room. It would make sense to let them do that for a while. Nothing replaces getting a ball in hand, getting onto a court and just playing around. That's how they learn to handle the ball, how they develop the dexterities that will be so important when they learn the game.

Naturally, they'll also be kicking the ball, holding it and running, and other things that won't end up part of basketball (they'll be parts of other games). At some point they'll need to learn what things are allowed and what aren't, and to work on basic skills: how to dribble, how to pass, how to shoot, the basic rules. These things they can learn from their parents or physical education teachers or other children.

So far, it's all just like science, and we'll get back to that in a moment. But here's the big difference: by the time they're learning not to dribble with two hands, most children are already starting to get a sense of the game as a whole. Unlike science, in basketball children have ready access to observe and think about play at more advanced levels. They can watch NCAA and professional games; they can watch older children and young adults at the gym or in the neighborhood. What does it do for them?

It helps with those basics, for one. Children who've seen proficient players dribbling have an image they can try to emulate. They've seen how the action moves up and down the court, and that helps them make sense of the rules

they've heard. It's one thing to hear a list of the rules; it's another thing to see how it all fits together in play. They still need to play around, and it's ok for them to do that without worrying about form, or setting up plays, or even dividing into teams, but as they develop a sense of the real game their playing around can start to take on more of its forms.

But there's much more than that. They can see how often professional players miss their shots and then just keep playing, which might help them learn that missing isn't so terrible a thing. On the other hand, when it is time to practice free throw shots, every child can imagine the tied game when they're at the free throw line with time running out—practicing becomes purposeful. Picturing what a real game looks like, they may learn to space themselves out around the court rather than all cluster around the ball, for example, as children starting out tend to do. It may help them learn to pass the ball around the court to their teammates, rather than holding on to it or shooting it whenever it comes into their hands.

As they learn, they notice and understand more of what they see in proficient players. Having played, that is, can make them more sophisticated spectators; that in turn can help them draw lessons at more sophisticated levels. They see a player pull off a fading jump shot, see how useful it is, and maybe they go try it themselves. They see players bending or breaking the rules during a game, and get a more nuanced sense of how that's part of the game too. It's illegal to carry the ball, for example, but the line between dribbling and carrying can get awfully blurry—at what point does the ref call a penalty? When does a player commit a foul on purpose?

Back to science

The vignettes illustrate what children can and will do with questions, if they're given a chance. Like children first learning to handle a ball, these children are playing around with ideas. They're asking questions, talking about causes and effects, reasons to believe and not to believe one thing or another, using what they've seen in the world and what they think makes sense to them. They're doing things that are as much part of the game of science as bouncing and throwing are part of the game of basketball.

For the same reasons that it's good to let children play around with a basketball, it's good to let children play around like this with ideas. Afterschool programs are terrific for that, not having the constraints of coverage and correctness that more and more govern school. Talking with each other is how children learn to be articulate, to form and respond to arguments, things most scientists will tell you they experienced at home and with their friends growing up.

Maybe that's why these aren't the first things that come to mind, for scientists thinking about education, because they learned them in the background and may take them for granted. But not all children have those sorts of experiences at home. Think of teaching basketball to a 10 year old who has never developed the dexterities of holding, throwing, and catching a ball. Remember how the ball

would hit you in the chest, before you learned the timing of when to move your hands together to catch it? For children who aren't accustomed to it, hearing a reasoned argument, much less responding to one, might be just as awkward. So they need to have time to play around. Naturally, they'll also be telling make-believe stories, inventing experiences they never had, and other things that won't end up part of science (they'll be parts of other activities). At some point they'll need to learn what things are allowed and what aren't in science.

Some of that they can learn in school, but the political and structural constraints keep the emphasis on the basics—foundational facts and concepts, how to take measurements and record data. These are certainly important. What's missing there is a sense of the game as a whole. Here is where NASA and other scientific institutions could contribute—not to help with the basic ideas, directly, which schools already address, but to give children what they have so easily in basketball: Access to the real thing, science as practiced by scientists.

This access could help children learn many things that are hard to get from school, especially if they can have that access through the less-constrained, less formal contexts of afterschool programs. We'll talk in a moment about what NASA might do to help; let's first talk quickly about the sorts of things students could learn about the nature and practice of science.

> **1) Science is driven by questions**. The first lesson learned in this report is to shift the focus of attention from knowledge, the information NASA missions use and produce, to questions. That's something children and scientists share, a common starting point. Like NASA scientists, the report tells us, children are captivated by questions about "the origin and nature of the planet, the solar system, and the universe." Of course, for scientists the posing of questions is a refined art, but that refinement starts from what children can do.
>
> So, children can learn, scientists devote their careers to big interesting questions, —"how did life start on earth?" and "how old is the universe?" This is something children do, and it's naturally motivating for them. They should understand and see for themselves that it's what scientists do too. As they gain in sophistication, they can learn how talking and thinking and arguing about these questions leads scientists to other questions, more narrow but testable, such as whether light from an explosion on the surface of a comet shows particular spectral lines, or whether radiation from empty space varies from one part of the sky to another. In the afterschool, children can have the freedom to talk, think, and argue about the interesting questions, and to let the possibility of testable implications emerge or not. In schools, the main agenda is to teach how to pose testable questions; what's missing is a sense of where these questions come from or why they're important.

2) Science progresses through argumentation. This is something else children share with scientists: They want to think things through for themselves, to express their ideas, and to argue for their views. That's what we could see the children doing in the vignettes, the 9- and 10-year olds providing arguments about whether objects were living or not— "a book is not dead because it was never alive anyways." If they could get a glimpse into what scientists do, they'd see how much it is about making arguments from evidence and logic, for or against one thing or another, how scientists are constantly in controversies and disagreements. For some children, arguments may feel like a bad thing, like fights, things to try to avoid. They need to learn the difference between fighting and intellectual discourse. Of course, scientists are more sophisticated in the ways they defend their views, but again it's a refinement of what children can do.

So children can learn what sorts of arguments scientists make, how they use evidence from what they've seen, how they may question it when it conflicts with other things they know or figure out. As they gain sophistication, children can learn how the need to answer other points of view leads scientists to use evidence to tie together a logical explanation, to use their intuition but also question it, to become systematic in trying to rule out one explanation in favor of another. For example, scientists control variables in experiments because they want to be able to answer what someone might argue. In the afterschool arena, children can have the freedom to arrive at these aspects of practice in responding to each other. There's less time for that in schools, where the purpose is to teach controlling variables as a component skill.

3) Mistakes are part of the game. That's so easy for them to learn about basketball, when they watch expert players shoot and miss. If they could watch scientists, they could see how often scientists find out they're wrong about a prediction or a conjecture, or even about something they weren't even trying to find out but just assumed to be true. They could see how mistakes have different significance at different points of a mission; how at early stages it's important to take risks and try things, not to worry too much about being wrong; how as the project progresses, much of the game is to discover the mistakes and correct them. Only at the end of the process, as they get ready for launch or publication, do scientists expect to have the right answers.

Here again, schools aren't set up to help children see science and learning in this way. State and national assessments won't value mistakes, and schools are concerned about scores. Students become afraid to be wrong, as crippling in science as a fear of

missing is in basketball; they can learn to hide their misunderstandings. The afterschool space is free from traditional evaluation, and children can take risks in ways that bring them closer to authentic science as it happens in NASA missions, at early phases and late.

How can NASA contribute?

The second recommendation in the report is to "Extract and concentrate on the NASA content that is most appropriate for afterschool science." What is most appropriate? We've talked about what it might mean to "focus on building understanding of the nature and practice of science" as objectives; we now turn to how NASA might help.

1) Start with what they can do. Rather than focus on what children do not know and cannot do that scientists could teach them, focus on what they do know and can do that could be the beginnings of science. They're interested and able to ask questions, to talk about their ideas, and of course to try things, so let these be starting places.

It's important to realize that it's essential for children to have these opportunities. At the outset, one of the most valuable things they can get from scientists is respect and encouragement for what they're doing. When children are trying to express their reasoning, to think about connections among ideas, to give arguments and counter-arguments, they are doing things that are part of science. Who better to help them appreciate that than scientists? And when they veer into make-believe or silliness, scientists can laugh along but help them see that these things aren't really part of the game in the same way.

2) Focus on questions. To start from what children can do, this has to mean different things at different levels. At the outset, children are motivated by some of the same questions that drive NASA missions, but they don't yet have the background knowledge to understand what NASA is doing. We think that's ok, when they're just getting started; as we said, it's like children first putting their hands on a basketball. For them, it might be enough to know what sorts of questions would interest scientists, and what sorts do not. Looking through the list in Table 3, "Is there life on every planet?" and "What are stars made of?" are perfectly reasonable scientific questions; but "Why was the moon made?" is not. An early goal in science education is to help children learn the difference—how better to learn that than from scientists?

As children become more sophisticated, the focus on questions can shift to be more specifically about what questions NASA

scientists are asking and how they are pursuing them. Schools already focus on traditional content; what NASA can provide that schools can't is a sense of the live questions driving science today. Where did these questions come from? Why and how did they become significant? How do questions of interest turn into questions for study?

This will be a challenge, to identify when children are ready for more background and details. At what point will children be ready to understand how the question "How old is the universe" leads to the question "What color light comes from distant stars?" We don't have any simple answers for that. The main point is to keep questions the central objective, the questions that drive passions and careers, and these can be understood at many levels of sophistication.

3) Highlight controversies and confusions. Thinking about what's of educational value from a mission, the first things that come to mind might be the results so far. But for children to learn how science progresses through argumentation, they need to be able to see some. At one level, they need to see, simply, that disagreements are not only inevitable, but productive; scientists like to find things to argue about, because arguments are opportunities for learning.

So it is helpful to display the controversies in NASA missions. Again, this can happen at different levels, depending on the students. Early, it may be enough for them to see that scientists argue in these ways; later, they can start to understand the specifics of a debate. Then the objective can be for them to see the logic and evidence on either side, even if—especially if!—the controversy is not yet resolved. If the main objective were students' acquiring knowledge, this might be counter-productive, because they'd hear conflicting ideas. But we second the reports' view that this shouldn't be the main objective; that's already the focus in schools. Instead, NASA can help afterschool provide something that doesn't happen in class, opportunities for students to see and experience how the game is played.

For the same reasons, it is helpful to display mistakes and confusions that happen in authentic science. Students need to see that scientists shoot and miss, as they do in basketball. It's not the same as having a teacher tell them it's okay that scientists make lots of mistakes; they'd get much more out of having access to particular examples and the people involved.

Closing thoughts

Certainly foundational ideas are important, but they're already in the state and national frameworks, and they're already at the center of the agenda for school science. Some people may argue that it isn't working in school. But maybe this is why: Children need a sense of the game as a whole. Without that, learning component facts and skills may not make much sense.

Children are already motivated to talk, ask questions, express and argue about their ideas. Starting from there gives us a different way to think about the objectives of science education and about what NASA has to offer, centered on activities for which children have interests and abilities and that are continuous with professional practices of science.

Education Standards, Achievement, and the Afterschool Program

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Introduction

Standards. School Achievement. Accountability. Funding. Are they connected? What are their implications, if any, for afterschool programs? In today's national education arena, "nearly every state, and most districts, has developed academic standards for what students should know and be able to do before graduating from high school. In fact, the No Child Left Behind Act now mandates that states implement statewide accountability systems based on challenging State standards" (Miller, 2003).

The hope and promise of this standards movement is that the outcome will impact school achievement, speak to accountability, and ensure future funding. However, in attempting to manage the content of the standards and align it with curriculum, a long-recognized issue emerges—the "large number of standards teachers must address given the finite amount of time available for instruction in the typical school day and year" (Miller, 2003). Thus, perhaps the greatest challenge in the standards movement has the greatest potential for impact on the afterschool learning environment—that of the element of time. "In the most optimistic scenario, educators have a total of 9,042 hours within which to teach and reinforce the 200 standards and 3,093 benchmarks." Based on conservative estimates, McREL researchers have determined that it takes about five hours to teach one benchmark. "...it would take 15,465 hours to cover all 3,093 benchmarks" (Marzano and Kendall, 1998). Clearly there isn't enough time in the school day to cover all of the standards. Note the emerging spotlight on the afterschool learning center. Are expectations heightened? What does the segue look like in the transition from the learning that happens in the formal classroom to the informal, afterschool setting?

Identifying Quality Materials

The essence of an afterschool program is the involvement of children in exciting new experiences in which the learning is embedded with fun. Afterschool programs are not bound by rigid time constraints or the pressure of large scale assessments. Therefore, afterschool programs are an ideal venue for many of the favorite activities that teachers simply cannot implement in today's formal education classrooms. How should afterschool providers determine appropriate materials for their programs?

In science and mathematics, there are an abundance of quality instructional materials that have the potential for adaptation for use in afterschool programs. One way to begin a search is to identify the topics that connect with the interest of the children being served. Content standards can be used as one way to

determine topics for consideration. The following are science and mathematics standards and topics that might be of interest to children: life science (anatomy/physiology, botany, cellular biology, ecology, genetics, zoology), physical science (chemistry, physics, and electronics), Earth science (geology, geography, weather/climate, oceanography), space science (solar system, cosmology, living and working in space), technology (design, engineering, forensics, computer science), science in personal and social perspectives (personal health, risks/benefits, ethics), and mathematics (algebra, geometry, probability, measurement).

NASA serves as an extensive repository for learning materials, as it invests heavily in the education of all students, with a special eye toward the next generation of scientists and engineers. NASA educational materials help afterschool providers deliver quality science, technology, engineering, and mathematics (STEM) materials, and thus address the "managing the standards and time" issue. However, the added benefit is a difficult reality that afterschool providers face daily—that of budget. Because NASA materials are generally disseminated at no cost via the World Wide Web in the form of portable document format (pdf) files, the materials cost to the afterschool provider is the cost of photocopying.

When selecting instructional materials for an afterschool program, providers should consider a number of criteria to assist them in making decisions. First, in thinking about the afterschool staff or facilitators that will be working with the children, it is important that there is sufficient background information on the topic. There should be descriptions of content (including images) that can be used by facilitators in order to gain competency and comfort in studying the topic with children. Second, while having a description of the education standards is not critical for afterschool programs, a listing of the standards will help facilitators and parents see connections to the formal education curriculum and provide a bridge for communication with teachers. Third, the activities in which the students are engaged in should be hands-on and minds-on. By that we mean that afterschool programs should focus on those activities that provide opportunities to involve children with multiple learning styles (i.e., visual, auditory, tactile/kinesthetic). To be sure, the best materials[b] for afterschool environments will involve children in active learning and provide them opportunities to ask questions, explore, and be curious about the natural and designed world. Fourth, providers should consider the amount of time that is available with the children and how much time the activities require. When planning for time, it is good to prepare for children who finish early or those who need extra time when completing tasks. Fifth, consider the types of materials

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[b] For each of these topics, there are many good options for instructional materials. They include hands-on activities, videos, computer simulations, and active learning games. Examples: Great Explorations in Math and Science (GEMS), Science Education for Public Understanding Program (SEPUP), and Full Option Science System (FOSS) all from U.C. Berkeley's Lawrence Hall of Science, government agencies (e.g., NASA, NOAA, EPA, USGS, NIH, NSF), informal institutions (e.g., Franklin Institute, Smithsonian, Exploratorium), media (e.g., PBS, Bill Nye, ABC News Classroom Edition, New York Times), and environmental projects (e.g., Project Wild, Project Learning Tree, Project WET).

that are necessary for children to be successful. Many instructional materials require only those types of materials that can be purchased in the grocery or discount department store. However, some may require special equipment that can only be purchased from a limited number of vendors. Finally, see if the instructional materials that are being considered contain pre- and post-activities for home use and/or additional resources for those children who are always craving more.

Computers Afterschool: Exit the Game Player; Enter the Project Maker

The "T" in STEM stands for technology, but all-too-often computers in the afterschool learning center signify the opportunity for students to engage in game play rather than use technology as a creative, project-based educational tool. How do you transition students from playing games to embracing multimedia applications? When given the right tools to help them create their own multimedia projects, the transition can happen with little resistance. As opposed to step-by-step solution finding, students who are drawn to electronic game play tend to solve problems using different techniques that might not typically be used in the formal classroom. "Having had to hone their skills in deductive reasoning, organizational strategies, and memory strategies, gamers come to the table seeing technology as their friend. They love playing, learning, experimenting, and watching technology work to its potential" (Prensky, 2001). As students are introduced to creative multimedia programs, their gaming opportunities help "prepare the soil" for learning cognitive skills through problem-solving strategies such as observation, hypothesis, and trial and error. Students are given the opportunity to focus their attention on important questions rather than textbook answers.

The availability of emerging technologies and freeware for the afterschool learning center has grown exponentially in recent years. What was considered unmanageable, costly, and Utopian before may now be manageable, affordable, and practical—opening up endless, student-oriented and student-centered opportunities. For example, with the use of NASA images online[c] and an image freeware program (listed below), students can create their own digital imagery projects—of the universe, space travel, the inside of the International Space Station, or a space shuttle cockpit. By using technologies[d] as tools, students begin to have a sense of visual connectedness, perceiving the world as their classroom, and will be able to incorporate question-oriented, outcomes-based styles of learning into their afterschool experience. Below are some freeware options for students who are interested in creating their own multimedia projects.

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[c] http://www.nasa.gov/multimedia/highlights/index.html

[d] http://cnets.iste.org/ The National Educational Technology Standards (NETS) Project is an ongoing initiative of the International Society for Technology in Education (ISTE). Those standards state that with technology applications, students will understand: 1) Basic operations and concepts, 2) Social, ethical, and human issues, 3) Technology productivity tools, 4) Technology communications tools, 5) Technology research tools, and 6) Technology problem-solving and decision-making tools.

Images:

> WPanorama (Win) Panoramic picture viewer and screen saver all in one. http://www.wpanorama.com/wpanorama.php
> 1-MoreMiniShiw 1.10 Select some pictures from your hard drive and this software creates a photo show.
> http://www.twocows.com/preview/389605.html

Audio:

> Quartz AudioMaster Freeware Record, compose, mix, play and share music using just a computer and a sound card.
> http://www.twocows.com/preview/193505.html

Web editing:

> WebDwarf This Web design editor combines a word processor, a vector geometry editor, an advanced rendering tool, and an FTP client publisher for HTML and SVG.
> http://www.tucows.com/preview/194497

Integrated Science Learning: Hands-On, Minds-On, Enthusiasm-On

At a park in Gloucester, Massachusetts, elementary school children scamper up ladders, slide down a fire pole, and play with block-and-tackle pulleys while learning physical science concepts like gravity, friction and force. Conceived by a parent and former science teacher, the Science Park was one school's solution to integrating science learning without adding to an already crowded curriculum and without contributing to teachers' feelings of being overwhelmed. What's more, the interactive science playground has inspired some innovative teaching methods that "go beyond words," as one fifth-grade teacher explained, and tap into a diverse range of learning styles (Laidler 2004). Informal education leaders and the afterschool community are looking for experiential, hands-on learning opportunities such as this: learning experiences that are school-relevant, but not necessarily school-like.

According to a non-profit Web site developed by educators as part of the UK National Grid for Learning[e], informal education embraces the following characteristics. First, informal education occurs in any setting from afterschool programs, to museums, to organized youth groups. Another defining characteristic is the central function of conversation among learners and the education leader. Such dialogue not only fosters learning and reflection, it is also the vehicle through which learners participate in decisions about instructional content. Furthermore, whereas formal education oftentimes follows a prescribed curriculum, informal education focuses on exploration and expanding learners' experiences (Smith 2005). This emphasis allows for considerably more freedom to follow learners' interests and take advantage of those teachable moments

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[e] http://www.infed.org/

that surface spontaneously through conversations with learners or in response to real-world events.

To unite efforts toward a scientifically literate society, improve coordination and consistency between the formal classroom and informal educational experiences, and help all educators stay current with trends in science education, Stephan Carlson and Sue Maxa developed the *Science Guidelines for Nonformal Education*[f]. Based on the *National Science Education Standards* and the *Benchmarks for Science Literacy*, the *Science Guidelines for Nonformal Education* identifies scientific inquiry process skills as well as content guidelines in life science, physical science, Earth and space science, and science and technology – to name a few. Furthermore, each of these guidelines is accompanied by sample hands-on science activities suitable for afterschool science programs[g].

Pedagogical models rooted in constructivist theory dominate in the realm of informal education and afterschool programs. The *Science Guidelines for Nonformal Education* highlights two models that are used in informal science education programs: the experiential learn-by-doing model and the youth-driven model. The learn-by-doing model consists of four stages that encourage learners to process an experiential activity. Initiated by an experience or by actually doing an activity, learners then generate new knowledge through reflection and social processes as they discuss the experience within a group setting. With leader guidance, learners generalize their learning experience by connecting it to real-world examples. Finally, learners apply their new understanding to a new situation. The youth-driven model, as the name suggests, promotes the idea of the learner directing his/her own learning. By offering learners freedom to choose content as well as the self-paced manner in which they learn it, the youth-driven model aims to instill a commitment to life-long learning (Carlson & Maxa, 1997). While constructivist approaches can certainly be found and implemented in formal classrooms, it is more difficult to enable learners to have control over their learning when curricular decisions are made at the state or local school district level.

Conclusion

While as a rule, the primary mission of today's afterschool program is to provide students with a safe place to spend time after the school day, a generally accepted secondary goal is to offer students the tools and skills that they need to become contributing members of society. Research suggests that the next education "standards arena" is the afterschool learning environment. Is there space for STEM subjects in today's afterschool program? Although the setting, instructional approaches, and learning processes may vary between formal and

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[f] The *Science Guidelines for Nonformal Education* distinguishes between informal education, found in museums, science and technology centers where learning is less directed, and nonformal education, including youth organizations such as 4-H, Scouts, Boys and Girls Clubs in which "organized systematic teaching and learning [is] carried on outside the formal school system with leadership from an adult or volunteer" (Walker, 1994 as cited in Carlson & Maxa, 1997).

[g] http://www.cyfernet.org/science/4h590.html#link2

informal science education, the driving educational purpose and vision should be the same – to promote scientific literacy, defined in the *National Science Education Standards* (NSES) as "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities" (National Research Council, 1996). Toward this vision, The NSES maps out the knowledge and skills needed to be scientifically literate at each grade level. Not only do the NSES provide guidance for educators in the formal classroom, they are intended to guide what happens in afterschool programs as well — "The school science program must extend beyond the walls of the school to the resources of the community" (National Research Council, 1996).

A quality afterschool program should be a coherent part of a child's total learning experience, and not a casual add-on to the end of the school day. To this end, afterschool providers who maintain an ongoing dialogue with the teachers of the students they serve will reap the rewards and potentially meet the hope and promise of impacting school and student achievement, speak to accountability, and ensure a sustainable future for respective, quality, afterschool programs nationwide.

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The Revolution in Earth and Space Science Education

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The other day I looked at an aged issue of the National Geographic. Dated April 1956, it presented an illustration of what the Earth looks like from space—not as photographed, but as illustrated by a top-notch group of scientists and artists. This was just before the dawn of the space age and all they could do was speculate. They imagined the view from above, seeing the green of vegetation, the white of snow-capped mountains, the blue/black of the oceans, the light browns of deserts, and the swirls of clouds.

They did a remarkably good job, considering that no one had ever seen the actual view, neither in person nor by remote camera. Yet by today's standards, the illustration looks almost quaint.

Fast forward from nearly 50 years ago to the present. The photo of the whole Earth as seen by the Apollo astronauts is seared on our collective consciousness. We see one world, awesome in its beauty. We have a near-permanent presence of humans in space, and dozens of satellites collect vast amounts of images and data about Earth. We see the rich spectacle of our home planet, not in our imaginations, but in hundreds of thousands of images taken by astronauts and satellites that reveal the subtle seasonal variations of vegetation, the flow of snow-packed glaciers on the Himalayas, the currents of the Gulf Stream, the vast Sahara, and the intricate patterns of clouds and storms. Looking beyond Earth, rovers explore the surface of Mars, spacecraft reveal the surface of Titan, and the Hubble telescope provides mesmerizing images and new understandings about our vast and mind-boggling universe. We've come a long way in the few decades since the National Geographic artists and scientists tried so nobly to envision the space-age perspective.

NASA has been at the forefront of a true revolution in Earth and space science. This revolution features a wealth of data and images, but it also encompasses and enables dramatically new understandings on the nature of our home planet, our solar system, and the universe beyond. Scientists think of the Earth not as discrete, disconnected pieces, but as an integrated whole, as dynamically interconnected systems. Solar energy heats the ocean, which feeds this energy into the atmosphere where the interplay of swirling air currents form a hurricane. This hurricane dumps large amounts of rain that flow into rivers, which carry sediment to the coast, extending the delta and reshaping the coast. While scientists knew of these systems, they now see them in process, the perspective of satellites and coordinated ground observations. Scientists can perceive in greater detail the subtleties and complex interconnections of the Earth system.

Here's one example:

To understand the mystery of why ships went faster up than down the Atlantic seaboard, Ben Franklin analyzed data gathered from ship logs. He was the first to identify and map the Gulf Stream—a large scale current in the Atlantic Ocean—as depicted in this map.

Benjamin Franklin's map of the Gulf Stream

Map of satellite data on Gulf Stream

While scientists progressed in their understanding of ocean currents over the next 200 years, the real quantum leap happened when we had satellite data of water temperature that mapped the Gulf Stream in much finer detail (see image to right). Scientists could see the motion of the current in the context of vast global patterns of energy flow and circulation across the Atlantic and Pacific oceans. They even discovered eddies of colder or warmer water (blue or red, respectively in this image) that would last for months, with their own local ecosystems. Satellites reveal Earth's processes with startling clarity.
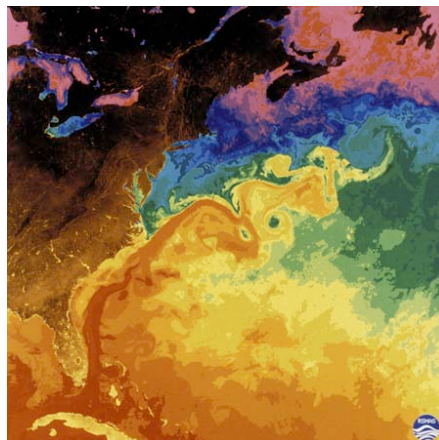
This scientific revolution has now become an educational revolution. The same images and insights from the space-age perspective are now fundamentally

transforming Earth science education. What was often perceived as a low-level course in high schools is now becoming a state-of-the-art, 21st century exploration of Earth system science. At the elementary- and middle-school levels, programs like GLOBE engage students in a worldwide science education and research project, with students collecting local observations for use by Earth scientists.

Recognizing the importance of this revolution, the National Science Foundation funded a conference of leading Earth scientists, educators, business leaders, and representatives of federal agencies (including NASA) to explore the challenges and opportunities for Earth and space science education. The conference recommended large-scale efforts to integrate these new tools, resources and understandings into standard classroom practice, launch professional development initiatives, and extend the reach beyond classrooms to informal learning environments. The *Revolution* report has become a key defining force for change, and the recommended strategies are being implemented in a range of research, development and implementation projects and policy reform initiatives.

This revolution extends well beyond the classroom. The Internet provides ready access to a vast wealth of images, data and learning resources of real interest to children and adults. NASA's web site is exceptionally popular, with millions of people exploring images from the Mars rovers, monitoring the return of the space shuttle, tracking missions to the outer planets and exploring images of Earth from space. Even the way we get our daily weather forecasts has radically changed, with many people going online not just to get the narrative forecast, but also to see satellite images of cloud cover and fine-tuning one's own local forecast by tracking radar maps of precipitation.

So, NASA's efforts to reach learners after school fit into the larger context of this revolution. For many people, NASA is magical and inspiring. Its explorations—"boldly going where no one has gone before"—are increasingly accessible from classrooms, homes, businesses, museums…and afterschool programs.

NASA Afterschool

Children in afterschool programs DO gravitate towards NASA experiences. Whether learning about Mars, exploring Earth from space, watching a launch, or doing experiments in astrobiology, children feel like they are part of something larger than themselves. They see the future as it unfolds—and that future is their home.

This is, in fact, new for all of us. It is new for the afterschool staff that may not be familiar with some of the core concepts, ideas and tools of the space age. And yet its newness makes it equally powerful as learning and exploring experiences for all of us. The staff and their students learn together. If a student asks "what is that?" the teacher can respond with "I don't know, let's learn

together." And that message is even stronger when even the scientists are trying to understand what they see.

Afterschool programs can make their contributions to the revolution by recognizing their role as enablers. They may or may not have the expertise to teach the underlying Earth or space science concepts. They may not understand how the sensors on the satellites work, or know which missions are on their way to which planets. But they can convey the excitement of learning, the spirit of exploration, and the experience of scientific inquiry.

How will we know if we succeed in exciting children about science? Certainly we'll notice if students ask for and look forward to NASA afterschool experiences. More deeply, we should see if students pay attention, outside the afterschool program, to the natural world around them. We should feel successful if students find Earth and space news in the media, or follow NASA missions on the Internet and bring this excitement back into the afterschool program. And at the highest level (literally), we should feel our efforts have succeeded when our afterschool students have grown into adults and wave down to us from their positions as astronauts in Earth's orbit or on their way to Mars and beyond.

Here are three examples of NASA resources that afterschool staff can tap into, and that illustrate the power of this revolution in Earth and space science education. While these were originally conceived for classroom use, they can be readily adapted for use in afterschool programs—especially since the afterschool environment generally supports such creative extensions.

> 1. ISS EarthKAM (www.earthkam.ucsd.edu) – This amazing NASA program enables middle-school students to photograph Earth from a window on the International Space Station. Students from hundreds of schools have been through the training to learn how to monitor the orbital track of the International Space Station, select interesting targets and send the requests to the camera. By now, several thousand images are available on the Web site for anyone to peruse. The images are fascinating, revealing Earth in wonderful detail. The fact that students took these pictures adds to their appeal. The images can be used as the launching pad for exploring Earth's rich variety of landscapes, comparing different cities, studying rivers or investigating agricultural patterns around the world. The web site includes learning activities from beginner to advanced levels.

> 2. GLOBE (www.globe.gov) – Children in over 100 countries around the world participate in this science and education program. Each participating class identifies a local study site where the students collect environmental measurements (atmosphere, water, soil, biology and so on) using protocols defined by scientists. This is a wonderful context for students to observe a site on an ongoing basis, watching seasonal variations

and comparing it with other sites around the world. Adding to the appeal of the project, the data are used by scientists doing authentic research on Earth system science. Afterschool programs might find it valuable to partner with a local school to help with the measurements, data submission and data analysis.

3. MarsQuest Online (www.marsquestonline.org) – The two Mars rovers (Spirit and Opportunity) are an inspiring success story. They both landed precisely and safely in their target locations, and (as of this writing) they both continue to explore. They are our surrogate eyes on Mars and have seen some amazing sites as they search for evidence of water in Mars' ancient past (if there was water, there might have been life). Equally amazing is the fact that we all can see the images at the same time as the scientists do(millions of people worldwide have done so). In partnership with NASA's Jet Propulsion Laboratory, MarsQuest Online receives and posts daily updates of all new images from the rovers. It is certainly a thrill to realize that you're seeing brand new images of another world along with scientists. The project also provides a series of learning activities to help "Mars naïve" visitors understand basic concepts about Mars, Mars exploration and the rovers. With hundreds of thousands of visitors to the site, it becomes clear that many have been bitten by the Mars bug!

For these projects to work in an afterschool program, the staff does not need to have any scientific expertise in Earth or space science (though some basic knowledge would help). And they don't need to be master science teachers (though a spirit of inquiry will help). In fact, the only real requirement is "susceptibility to enthusiasm." Once the spark is ignited, the rest can fall into place. Sure, the staff will need to learn and prepare and be open to creative experiences, but fundamentally, the revolution is fun—and inevitable.

Note: For a copy of the report of the National Conference on the Revolution in Earth and Space Science Education, go to www.EarthScienceEdRevolution.org. To tap into NASA's vast wealth of online resources, got to www.nasa.gov

Trends in Science Education – An Essay[h]

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We arrive at the beginning of the 21st Century with new agendas, challenges, insights and issues facing science education.   The "Post Standards/Benchmarks" view of K-12 science education has consolidated perspectives about what and how to teach, what and how to assess, and what and how to design learning environments. The No Child Left Behind (NCLB) act has fundamentally shifted priorities in public education. The research on learning and reasoning from the cognitive sciences over the last 20 years has ushered in new and important ideas concerning the science of learning (Bransford, et al 1999) and the role of assessment in learning (Pelligrino, et al 2002). In addition to these two influential National Research Council reports, NRC reports on the research base for teaching and learning reading (Snow, et al, 1998), mathematics (Kilpatrick, et al, 2002), and the forthcoming report on science learning K-8, are heralding new guidelines for the design of curriculum, instruction and assessment models and new principles for design of learning environments.

There are other developments that factor into the climate of change for science education.   A new framework for NAEP Science 2009 is underway with specific recommendations from NAGB (Champagne, et al, 2005) about the importance of taking the assessment of science learning beyond questions of what we know toward the inclusion of test questions addressing how we know and why we believe what we know. New computer tools and technologies both in the classrooms and in support of classrooms and schools are making possible new forms of information that can (1) guide teachers in assessment for learning as well as assessment of learning and (2) bring to classrooms data bases to promote inquiry and engagement in complex scientific/mathematical reasoning. Yet, we are a nation, a global civilization that is undergoing dynamic changes: political, economical, environmental, social and technological.

The purpose of this essay is to bring attention to some of the prominent trends in science education that represent 'good bets' for changing the practice and the goals of K-12 science education. Specific attention is given to inquiry, the nature of science, and science and technology standards.. The essay is organized in to 4 sections: an Overview, and sections labeled Philosophy, Psychology and Pedagogy. Each "P" section represents an important domain that provides guiding frameworks to shape science education. Respectively, the Philosophy section will examine views about the nature of science, the structure of scientific knowledge and the criteria used to determine "what counts" as scientific knowledge. The Psychology section will examine the recent research on learning and reasoning with respect to education practices. The

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[h] Major portions of this Essay are based on and include ideas found in Duschl & Grandy (2005), Duschl (2003), Duschl & Osborne (2002). Interested readers are referred to these full papers for an in-depth treatment of the trends discussed.

Pedagogy section will examine important overlaps and congruencies among the 3 Ps that play out in the design of learning environments and the design of curriculum, instruction, and assessment models.

Overview

Since the first NSF funded era of science education reform in the 1960s and 1970s, we see a shift from science as experimentation to science as explanation/model building and revision; from learning as a passive individualistic process to learning as an active individual **and** social process; from science teaching focusing on the management of learners' behaviors and "hands-on" materials to science teaching focusing on the management of learners' ideas, access to information, and interactions among learners. Some of the shifts have been motivated by new technological development but new theories about learning have contributed too.

One important change that has significant implications for a view of school science concerns the realm of scientific observations. Over the last 100 years new technologies and new scientific theories have modified the nature of scientific observation from an enterprise dominated by *sense perception,* aided or unaided*,* to a *theory-driven* enterprise. We now know that what we see is influenced by what we know and how we "look"; scientific theories are inextricably involved in the design and interpretation of experimental methods.

New technologies and learning theories also have effected how we monitor, diagnose and nurture learning. Scientific databases like Geographical Information Systems (GIS) make it possible to engage in rich scientific inquiry without engaging in hands-on science involving the collection of data. Instead, the data are provided and the inquiry begins with the selection of information for analysis. This is one example of how science education has shifted from management of materials for collecting data to management of information for scrutinizing databases. Such a shift has implications regarding the manner in which interactions with phenomenon are designed and included in science lessons for all grade levels*.* Information in the guise of data, evidence, models and explanations represents, in an important sense, the new materials for school classrooms and laboratories. Taken together these developments in technologies and theories have implications for how we conceptualize the design and delivery of science curriculum materials for purposes of supporting students' learning as well as teachers' assessments for promoting learning. The use of computer-supported instrumentation, information systems, data analysis techniques, and scientific inquiry practices in general, has created a problem. The language of science in schools and in the media has not kept pace with the language of scientific practice--apractice that is decreasingly about experiments and increasingly about data and data modeling. In brief, one could argue that causal explanations grounded in control of variable experiments have largely been replaced by statistical/probabilistic explanations grounded in modeling experiments. The language of science in each experimental context is different. A reconsideration of the role of inquiry in school science must address this

language gap and herein lays the importance of promoting scientific discourse practices.

Philosophy

The NSES content goals for inquiry focus on students' abilities to pursue inquiry and to understand the nature of scientific inquiry. Images of inquiry is one place were science education has not kept pace with developments in science. That is, science education continues to be dominated by hypothetico-deductive views of science. This conception of science is closely related to traditional explanations of "the scientific method." The steps in the method are:

1. Make observations
2. Formulate a hypothesis
3. Deduce consequences from the hypothesis
4. Make observations to test the consequences
5. Accept or reject the hypothesis based on the observations.

Philosophers of science have argued, however, that the HD View is an incomplete view of scientific inquiry. Scientific inquiry has other equally essential elements: *theory development, conceptual change, and model-construction*. This is not to imply that scientists no longer engage in experiments. Rather, the role of experiments is situated in theory and model building, testing and revising, and the character of experiments is situated in how we choose to conduct observations and measurements; i.e., data collection. The danger is privileging one aspect of doing science to the exclusion of others.

Twentieth century developments in science studies can be divided into three periods. In the first, logical positivism, with its emphasis on mathematical logic and the hypothetico-deductive method was dominant. Some of the major figures in the movement were Rudolf Carnap, Carl G. Hempel, Ernest Nagel, and Hans Reichenbach. In the 1950s and 60s, various writers questioned many of the fundamental assumptions of logical positivism and argued for the relevance of historical and psychological factors in understanding science. Thomas S. Kuhn is the best known figure in this movement, but there were numerous others, including Paul Feyerabend, (1993) Norwood Russell Hanson (1958), Mary Hesse (1966), and Stephen Toulmin (1959, 1961). Kuhn (1962/1996) introduced the conception of paradigm shifts in the original version of *Structure of Scientific Revolutions*, and then revised it in the postscript to the 1970 second edition, introducing the concept of a disciplinary matrix. One important aspect of Kuhn's work was the distinction between revolutionary and normal science. Revolutionary science involves significant conceptual changes, while normal science consists of "puzzle solving", of making nature fit into the boxes specified by the disciplinary matrix. In this "puzzle solving" view of science, theories still played a central role, but they shared the stage with other elements of science, including a social dimension. Although Kuhn saw the scientific communities as essential elements in the cognitive functioning of science, his

early work did not present a detailed analysis this cognitive element of scientific inquiry.

The "model-based" movement in philosophy of science can be seen as filling in some of the gaps left by Kuhn's demolition of the basic tenets of logical positivism. This movement:

1. emphasizes the role of models and data construction in the scientific process and demotes the role of theory;
2. sees the scientific community as an essential part of the scientific process
3. recognizes the cognitive scientific processes as a distributed system that includes instruments.

Among the major figures in this movement are Nancy Cartwright, Ron Giere, Helen Longino, Nancy Nersessian, Patrick Suppe, Fred Suppes, among others.

Developments in scientific theory coupled with concomitant advances in material sciences, engineering, and technologies have given rise to radically new ways of observing nature and engaging with phenomenon. At the beginning of the 20th century scientists were debating the existence of atoms and genes, by the end of the century they were manipulating individual atoms and engaging in genetic engineering.

These developments have altered the nature of scientific inquiry and greatly complicated our images of what it means to engage in scientific inquiry. Where once scientific inquiry was principally the domain of unaided sense perception, today scientific inquiry is guided by highly theoretical beliefs that determine the very existence of observational events (e.g., neutrino capture experiments in the ice fields of Antarctica).

Historically, scientific inquiry has often been motivated by practical concerns, e.g., improvements in astronomy were largely driven and financed by the quest for a better calendar, and thermodynamics was primarily motivated by the desire for more efficient steam engines. But today scientific inquiry underpins the development of vastly more powerful new technologies and addresses more pressing social problems, e. g., finding clean renewable energy sources, feeding an exploding world population through genetically modified food technologies; and stem cell research. In such pragmatic problem-based contexts, new scientific knowledge is as much a consequence of inquiry as the goal of inquiry.

Psychology

Research on cognitive factors, like the role of prior knowledge and strategic knowledge, and on social and cultural contexts that engage and support language use and learning are helping to redefine our notions and ideas about effective schools and classrooms. Recent research (Kuhn, 1999) on the development of critical thinking skills, shows how our emerging knowledge of children's intellectual development can be described on three cognitive

dimensions. One is metacognitive processes (knowing how to learn), two is metastrategic processes (knowing which strategies to deploy), and three is epistemological framework (an understanding of how we know). Kuhn argues that a consideration of these three dimensions can be used to enrich our visions of good practice by offerings us multiple aims for the constituents of an effective education. More significantly, an emphasis on metacognition changes the conception of the student from that of a receptor of information to one who is an active constructor of knowledge. Where:

> 'To be competent and motivated to "know how you know" puts one in charge of one's own knowing, of deciding what to believe and why and of updating and revising those beliefs as one deems warranted. To achieve this control of their own thinking is arguably the most important way in which people both individually and collectively take control of their own lives.'   (Kuhn, 1999)

An explanation for the paucity of student-centered "enquiry into enquiry" rests on a failure to adopt curriculum and instruction strategies that integrates the social (used here to refer to the discursive modes and contexts by which scientific information and knowledge are communicated and represented) and the cognitive aspects of engaging in scientific enquiry. For there now exists a body of research (Bransford, et al, 1999; Pellegrino, et al, 2002) that supports the integration of both the social and cognitive dimensions of learning and reasoning. There also exists compelling research that speaks to the importance of establishing structures that enable students to engage with science in classrooms in communities of practice that facilitate modes of discourse which more closely resemble those of the scientific community. In such communities, students would be encouraged to question, to justify and to evaluate their own, and others' reasoning, enculturating the students as learners into discourse processes that support personal knowledge construction and student metacognition.

Robert Glaser (1995), in a major review of how psychology can inform educational practice, develops and outlines the components of a coherent learning theory that can inform instruction and illuminates how Kuhn's approach might be achieved. He identifies seven research findings that inform us about the structure and design of learning environments – aspects of which are further elaborated in *How People Learn* (Bransford, Brown & Cocking, 1999). The seven findings are:

   1. *Structured Knowledge* - "Instruction should foster increasingly articulated conceptual structures that enable inference and reasoning in various domains of knowledge and skill." (p. 17)2. *Use of Prior Knowledge and Cognitive Ability* - "Relevant prior knowledge and intuition of the   learner is . . . an important source of cognitive ability that can support and scaffold new learning . . . the assessment and use of cognitive abilities that arise from specific knowledge can facilitate new learning in a particular domain." (p 18).

3. *Metacognition,Generative Cognitive Skill* - "The use of generative self-regulatory cognitive strategies that enable individuals to reflect on, construct meaning from, and control their own activities . . . is a significant dimension of evolving cognitive skill in learning from childhood onward . . . These cognitive skills are critical to develop in instructional situations because they enhance the acquisition of knowledge by overseeing its use and by facilitating the transfer of knowledge to new situations . . . These skills provide learners with a sense of agency." (p. 18).

4. *Active and Procedural Use of Knowledge in Meaningful Contexts* - "Learning activities must emphasize the acquisition of knowledge, but this information must be connected with the conditions of its use and procedures for its applicability. . . School learning activities must be contextualized and situated so that the goals of the enterprise are apparent to the participants." (p. 19, emphasis in original).

5. *Social Participation and Social Cognition* - "The social display and social modeling of cognitive competence through group participation is a pervasive mechanism for the internalization and acquisition of knowledge and skill in individuals. Learning environments that involve dialogue with teachers and between peers provide opportunities for learners to share, critique, think with, and add to a common knowledge base." (p. 19).

6. *Holistic Situations for Learning* - "Learners understand the goals and meanings of an activity as they attain specific competencies . . . Competence is best developed through learning that takes place in the course of supported cognitive apprenticeship abilities within larger task contexts." (pp. 19 -20).

7. *Making Thinking Overt* - "Design situations in which the thinking of the learner is made apparent and overt to the teacher and to students. In this way, student thinking can be examined, questioned, and shaped as an active object of constructive learning." (p. 20).

Prominent in the components of effective learning environments identified by Glaser is recognition of the important role that prior knowledge, context, language and social processes have on cognitive development and learning. Such components are not marginal but centrally important to the process of learning. Such understandings have guided many educational researchers to now conceive of thinking and reasoning as acts that are socially driven, language dependent, governed by context or situation, and involving a variety of tool-use and cognitive strategies. These newer conceptions of learning respectively see *cognition as social* (in that it requires interaction with others), *cognition as situated* (in that it is domain specific and not easily transferable), and *cognition as distributed* (in that the construction of knowledge is a communal rather than an individual activity). The various programs of research conducted and coordinated by cognitive, social, developmental, and educational psychologists now present a more coherent and multi-faceted theory of learning that can inform the design of learning environments (Bransford, Brown & Cocking, 1999). In science education, we can interpret this to mean that students must have an opportunity to engage in activities which require them to use the language and reasoning of science with their

fellow students and teachers – that is to engage in the construction and evaluation of scientific argument.

Pedagogy

Science distinguishes itself from other ways of knowing by appealing to evidence that is deemed objective by its practitioners and then using the evidence to put forth testable explanations. Scientific ideas and information are rooted in evidence and guided by our best-reasoned beliefs in the form of the scientific theories that frame investigations and inquiries. All elements of science -- questions, methods, evidence and explanations -- are open to scrutiny, examination, justification and verification. *Inquiry and the National Science Education Standards* (2000) identify five essential features of classroom inquiry:

- ·Learners are engaged by scientifically oriented questions.
- ·Learners give priority to **evidence**, which allows them to develop and evaluate explanations that address scientifically oriented questions.
- ·Learners formulate **explanations** from evidence to address scientifically oriented questions.
- ·Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
- ·Learners communicate and justify their proposed explanations. NRC (2000)

The bold emphasis on evidence and explanation appears in the original. Science at its core is fundamentally about acquiring data and then transforming that data first into evidence and then into explanations. The point I want to make here is that preparation for making scientific discoveries and engaging in scientific inquiry is linked to students' opportunities to examine the development and unfolding or transformations of data across the evidence-explanation (EE) continuum. The strategy I propose is to allow students to make and report judgments, reasons, and decisions during three critical transformations in the E-E continuum. One is selecting data to become evidence. Two is analyzing evidence to generate models and/or locate patterns of evidence. Three is locating or otherwise determining the scientific explanations that account for the models and patterns of evidence.

In each of the three transformations, students are encouraged to share their thinking by engaging in argument, representation and communication, and modeling and theorizing. In each of the three transformations, teachers are to engage in assessments of inquiry by comparing and contrasting student responses to each other and, importantly, to the instructional aims, knowledge structures, and goals of the science unit.   The point being made is that effective assessments of science inquiry will examine students' beliefs and decision-

making concerning the transformations of data to evidence, evidence to patterns or models, and patterns/models to explanation.

Another appeal to adopting the E-E continuum as an instructional framework for guiding the planning and/or design of curriculum, instruction, and assessment models is that it helps slow down the pace of instruction and, thus, helps facilitate assessment of inquiry. The unfolding of data takes time and this is another reason why effective inquiry units are longer in length. By pausing instruction to allow students to come together and discuss and debate what they know, what they believe, and what evidence they have to support their ideas, thinking is made visible thus enabling monitoring and assessments of the communication of information and of the thinking.

The commitment here is to curriculum frameworks that (1) promote full or extended instructional sequences rather than partial or short single lesson instructional sequences and (2) intentionally embed into the instructional sequence assessment-driven activities that facilitate feedback on the conceptual, epistemic, and social goals of the unit. Typically, we are looking at units that are two-four weeks in length, sometimes longer. The additional time is needed to make room for student conversations and representations of reasoning that, in turn, make possible assessments of inquiry. The significant trade-off that needs to be made is holding down the number of concepts, science terms and labels so that the data-driven elements of scientific inquiry can be examined and debated. The NSES recommend that at each grade level K-12 students be given the opportunity to complete at least one full-inquiry unit. Full-inquiry or immersion unit approaches adopt a model of science instruction that situates learning within design, problem, or project contexts. The design, problem, or project based immersion units represent four-six week-long lesson sequences that are situated within a compelling context to motivate students and to advance rigorous learning. Furthermore, in order to support learning, the immersion units typically contain tasks that help make students thinking visible and thus provide teachers with valuable insights about how to give feedback to students in each of the three goal domains:

> promoting the communication of scientific ideas,
> developing scientific reasoning,
> developing the ability to assess the epistemic status that can be attached to scientific claims.

The goal is to assist learners with both the construction and the evaluation of knowledge claims. Thus, by design, students are given extended opportunities to explore the relationships between evidence and explanation. To this end, inquiries are situated into longer thematic instructional sequences, where the theme is defined not by the conceptual structures of scientific content alone. Rather, the sequence of inquiries is designed to support acquisition and evaluation of evidence, as well as language and reasoning skills that promote progress toward a meaningful inquiry goal; e.g., the design, problem or project. The shift from a content/process focus of science education to an evidence/explanation focus has significant implications about the role of inquiry

in school science.

Fundamentally important to the success of conducting assessments along the EE-continuum is capturing the diversity of thinking found in students' judgments and decisions. One important dynamic is to always ask students to provide reasons and evidence to back up the judgments and decisions they make. When students are requested to explain or justify their results, judgments, and decisions with reasons and evidence, their thinking is made visible and several important assessments of inquiry can now take place.   For example, a common strategy for making students' thinking visible is to ask each student or group of students upon completion of an investigation to place their data into a class data table either on a board, overhead transparency or computer data file. Making public the display of data facilitates discussion about what data to use as evidence. The class data table may reveal, among other things, errors and successes in measurement and in data recording (e.g., placement of decimal points; use of formulas) and, importantly, students beginning sense of patterns in the data (e.g., the 2nd transformation in the EE continuum). Discussion about the class data table my reveal that more data is needed to complete the inquiry or that the data being collected can't be used to answer the questions being posed.

Through the review and discussion of data, mediated and guided by the teacher employing assessment strategies, students will begin to develop a sense of the criteria used to understand 'what counts' as good data. Students begin to learn that scientific inquiry involves asking questions of the data and using the data to ask new questions.   Full inquiry instructional sequences make provisions for just such occurrences.   An excellent source of instructional strategies to use with students for handling the analysis and reporting of data is *Investigating Real Data in the Classroom* (Lehrer & Schauble 2002). You will find in this edited volume chapters written by classroom teachers that examine successful strategies they have used to get young students working with data.

Another instructional strategy that promotes assessments of what counts as data and evidence is providing students with options for obtaining the data. In other words, give the students choices with how they will collect data and then ask them to justify their choices. The choices and the reasons provided to support choices create another kind of assessment opportunity about students' thinking and reasoning. Many kit-based science investigations in the interest of time to 'cover' the content are structured so that all students use the same equipment, probe the same question, and use the same materials. When the outcomes are the same, what's there to discuss and debate? Monolithic knowledge does not engender scientific reasoning or critical thinking. The goal during science inquiry lessons is to create conditions that stimulate diversity among students' responses. A key dynamic to effective assessment of inquiry is exposing the different reasons and beliefs students hold precisely because it engenders communication of ideas and argumentation about ideas, both essential features of scientific inquiry.

The lesson sequence approach, referred to as full-inquiry or immersion units, stands in stark opposition to single lesson approaches that partition concepts and processes. Osborne and Freyberg (1985) report that students' understandings of the goals of lessons do not match teacher's goals for the same lessons. When students do not understand the goals of inquiry, negative consequences for student learning occur (Schauble, Glaser, Duschl, Schulz & John, 1995). Unfortunately, the single science lesson approach is the dominant practice found in schools. By situating science instruction and learning within a design-based, problem-based, or project-based context, to which members of the class have both individual and group responsibilities, a very different classroom learning environment develops. Specifically, the design of thematic instructional sequences allow us to approach closer to an understanding of the developmental landscapes located within domains of science learning; landscapes that do not presuppose a single developmental trajectory or path but do require a clear understanding of the conceptual, epistemic and social developmental goals within a unit of science instruction.

Conclusion

When we synthesize the learning sciences research, the science studies research and science education research we learn that:

(1) The incorporation and assessment of scientific inquiry in educational contexts should focus on three integrated domains:

> The **conceptual** structures and **cognitive** processes used when reasoning scientifically,
> The **epistemic** frameworks used when developing and evaluating scientific knowledge, and,
> The **social** processes and contexts that shape how knowledge is communicated, represented, argued and debated.

(2) The conditions for science inquiry learning and assessment improve through the establishment of:

> Learning environments that promote **student centered learning**,
> Instructional sequences that promote **integrating science learning** across each of the three domains in (1),
> Activities and tasks that **make students' thinking visible** in each of the three domains, and
> Teacher designed assessment practices that **monitor learning and provide feedback** on thinking and learning in each of the three domains.

There are several trends that are altering our images of science education:

> From having as a goal providing science education for scientists, to providing science education for all;
> From an image of science education as what we know, to science education as teaching science as a way knowing;

From an image of science education that emphasizes content and process goals to science education that stresses goals examining the relation between evidence and explanations;
From an emphasis on individual science lessons that demonstrate concepts, to science lesson sequences that promote reasoning with and about concepts;
From the study of science topics that examine current scientific thinking without regard for social context, to the study of science topics in social contexts;
From a view of science that emphasizes observation and experimentation, to a view that stresses theory and model building and revision;
From a view of scientific evidence principally derived from sense-perception (either direct or augmented) to a view that evidence is obtained from theory-driven observations.

Full inquiry or immersion units promote the meaningful learning of difficult scientific concepts, the development of scientific thinking and reasoning, the development of epistemological criteria essential for evaluating the status of scientific claims and the development of social skills concerning the communication and representation of scientific ideas and information. Providing students with opportunities to engage with natural phenomenon and to link evidence to explanations is vital.

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Afterschool Program Staff and Science Instruction: What We Bring to the Table

Emilio de Torre, Director of Education, Madison Square Boys and Girls Club

Over the past several years, there has been an increased emphasis to promote science education in the afterschool community. Unfortunately, most sources employ a deficit model approach when examining the role of after school personnel as facilitators of science activities or instructional providers. Due to the inherent differences between schools and out of school time programs' atmospheres and youth development philosophies — the community based organizations' staff actually possess many unique capabilities and approaches that assist in promoting science education in ways not often achievable in a school setting.

The predominating afterschool organization is a non-profit business serving underprivileged or under-resourced youth between the ages of 6 – 18. Most often the majority of the program participants are 7 to 14- year -olds. As a result, out of school time science programs fall into four categories:

> *Traditional academic education* (e.g., grade appropriate science tutoring or remedial science, research for homework or school projects, etc…);
> *Inquiry based learning projects/exposure* (e.g., AMNH/NASA astrophysics program, partnerships with local zoos and parks departments, maintaining aquaria & terraria, etc…);
> *Infrequent or "stand alone" events* (e.g., science fairs, IMAX presentations, museum trips, etc…);
> *Ancillary or tangential science modules or threads branching from a "non-science" program* (e.g., the physics of billiards or internet research on UFOs).

Tutorials aside, events such as trips to museums or teachable moments resulting from a youth's spontaneous questioning during an activity, have all too frequently been the only science opportunities that children have been able to experience in the afterschool arena. Recently there has been renewed emphasis on daylong learning opportunities due to increased concern and funding from the government and various corporations and foundations. Subsequently, community based organizations (CBO's) have been better positioned to present science experiences for their youth participants in the past few years.

Until the last fifteen years or so, most afterschool staff has focused on organized recreation, arts & crafts, homework help and youth development — emphasizing leadership development, cooperative social development, conflict resolution, following instructions and fair play. Now specialized programs such as gang intervention, pregnancy prevention, small group tutorials, and computer instruction run in conjunction with these more prevalent types of activities.

Because of the less academic nature of these programs, youth organizations and staff have been able to adapt very different approaches for implementing instruction.

In this type of environment counselors focus more on the social development of the child and less on fostering the atmosphere of "right answer/wrong answer" that you may find in schools. As a result, acronyms such as BUIC (belonging, usefulness, influence, competency) have become workplace philosophies for the staff. In the Boys & Girls Club movement, all programs and activities are intended to have BUIC as their core motivation. Staff members are encouraged to ask themselves: "Does this program foster a sense of belonging for the child? Does the participant feel useful in this program? Does the member have an influence on what we are doing and saying here? Am I helping to develop a sense of competency in this child?"

With this refreshing perspective as the basis of the staff's actions and program design, children are allowed to leave the school-based world of memorization, standardized testing, right answer/wrong answer dichotomy, and hand raising call-and-response instruction and enter an environment where play, adventure, inquiry, experimentation, and expression are the fostered behaviors.

Workplace philosophies aside, there are numerous characteristics that afterschool staff possess that set them apart as unique instructors. Developmental areas that may have initially been determined as a deficit to instruction are not so much areas of professional underdevelopment or inexperience, as areas that may call for a different type of instructional strategy or a different objective other than a traditional school based teaching style. For example, most afterschool counselors are part time employees - young adults between the ages of 17 and 23. The younger participants therefore easily recognize them as role models who bring relevant cultural information. More so than a teacher, young staff members are emulated and looked up to. The staff's enthusiasm is an ever-present catalyst to motivate and inspire children. As a result, participants are more willing to explore new topics in science and current events if they believe that their role models feel this is significant. This is quite different from the reaction and/or respect a group of students will give a cluster teacher who comes to their classroom once or twice a week to bring them science on a cart.

Obviously the science background that professional teachers possess is superior to the average afterschool counselor. Years of training and academic rigueur have calibrated them to teach science as full time employees of their city, county or state. They are able to embrace and incorporate the national or state standards and rubrics, as well as create lesson plans in and around the chosen texts and workbooks. In addition, they possess the relevant experience to answer or explain any questions the students may have pertaining to their science lessons. In most instances, these professional teachers have been serving their school system for many years. Unfortunately, many elementary school teachers in particular are not trained in science instruction, and with the renewed national emphasis on literacy and mathematics it becomes much more

difficult for the teacher to receive the appropriate training or support to implement effective science classes. It is far easier for the teacher to rely on basic textbook instruction, e.g. reading and response, than any of the other more engaging approaches to science instruction.

On the other hand, it is the lack of formal academic or professional science experience that enables afterschool counselors to be more open to embracing new learning techniques and styles, while at the same time allowing them to explore along with the children. With a minimum of training in program management and result oriented program design, the afterschool staff is able to incorporate a motivating youth development philosophy into the science program. Without the academic professional training it is easier for the staff to remove itself from the classic "right answer/wrong answer" dynamic and follow a more inquiry-based teaching style. This creates an atmosphere different from the classroom, wherein not knowing the answer is less frightening. The staff will then be able to question why things are the way they are along with the children, fostering a co-inquiry learning model within a nurturing environment. This promotes the idea that both the afterschool staff and the members are lifelong learners together.

Because of the connotation of a teacher being a paragon of omniscience, it is much easier for a child to embark on a learning adventure with a trained afterschool counselor as a guide. If the children believe the counselors to be a co-inquirers, they will be encouraged to pursue a more assertive role in researching or experimenting than they might if they expected their teachers to know the correct answers and/or judge them for failing to know the answers. In an environment where exploration and play are allowed and encouraged, it is much easier for the staff to expose children to new concepts and allow them to investigate these subjects in a way very different from a typical school setting.

The same lack of exposure to formal science that causes children to relate to what they see in a science activity to prior experiences and familiar objects, motivates the afterschool staff in similar fashion. Many staff members are able to relate better to their participants' opinions and conjectures about the specimens or the phenomena they witness, because they too are not overly familiar with what they are experiencing. It is easier for both the staff and youth to draw parallels and analogies to occurrences and objects in their daily lives. Hence, the shared experience draws the two groups closer and emphasizes the activity all the more because they are relating the results similarly. Even if the relationships are not identical to one another, they are both drawing comparisons and therefore processing the event in the same way, thereby diminishing the gap between the instructors and the instructed.   Conversely, this dynamic also creates a greater desire for activities with "flash appeal," e.g. spectra, chemical reactions, and anything mysterious or dramatically unfamiliar. For better or worse, many science (and pseudo-science) activities and discussions were sparked after FOX Television aired the alien autopsy special several years ago. This shared television phenomenon inspired afterschool staff and youth all around the United States to inquire about topics as diverse as

cryptozoology, astrophysics, virology, anatomy and famous hoaxes from the past, such as the Piltdown man and the DaVinci Code.

Probably the greatest asset that afterschool staff can offer is its ability to create "buy in". Because afterschool programs are voluntary, children vote with their feet. This means that if a program holds little to no interest for a participant, they will literally stop coming and go elsewhere — to another activity, a new room, or an entirely different afterschool facility. Subsequently, staff members need to be professional motivators who work to create a feeling of "buy in" among the children as well as other staff. Each and every member of the afterschool team promotes its programs as exciting, vibrant and needed parts of every child's day. As a result, afterschool facilities have combined their philosophy and inherent enthusiasm for the child's wellbeing, with sales techniques to broadcast and "hype" their activities. By and large, members want to be in every activity in which they can be active participants.. There is no report card looming over their heads. The children don't get held over if they don't perform to grade expectations. Staff members and the participants know this, so the staff works doubly hard to command interest and respect. Children spend time with those who do this best.

In addition to motivation, low staff-to-youth ratios also provide golden opportunities for relationship development as well as instruction. Almost all cities and states have mandatory guidelines for staff-to-youth ratios, e.g. New York City requires that a ratio may not be greater than 1:10 for children less than 14 years of age. The United States Department of Education reports that the average national ratio for before and after school programs was 1:8.9. Most teachers only daydream about the impacts they would be able to make if their class ratios could be only twice that size.

There are many challenges confronting afterschool staff and staffing. Non-profit recruitment and retention obstacles are notorious. Non-profit afterschool programs are frequently under budgeted, don't offer competitive salaries, and provide few or no tenured positions. The staff may not have hadadequate training, experience, or education and may be encouraged to stress certain activities to the detriment of other activities. Because of budget constraints the necessary resources or materialsmay not be available.. In addition, funding sources may dry up necessitating staff layoffs; With these all-too-frequent realities in mind, it is vital to recognize and develop the many positive resources that non-profits do offer. Often, a deficit-model approach is adopted in the exploration of using out of school time facilities as a method of expanding science education. If the desired objectives for science in an afterschool setting are different from the expected objectives of a school-based science program however, the synergy between the two may result in beneficial and rewarding outcomes for both staffs and youth. By using different sources and employing multiple approaches toward science , the relevancy and significance of science will become more pertinent to the children.

The importance and necessity of a classic approach to science and scientific inquiry cannot be overvalued. It is vital that children study and memorize hundreds of key elements (pun intended). The current climate sees the

importance of science in the school increasingly diminished as literacy and mathematics, due to underperformance in these areas, are more and more emphasized. Many professionals are worried that science is going the way of arts and music in our school systems.That is to say, the way of the dinosaur. While science in an afterschool setting can never replace school-based science, the many unique advantages that the afterschool staff can offer is a resource that has beenoverlooked. It is a resource that can provide the essential motivation, the desire, the inspiration and the encouragement for children to be inquisitive and take a refreshing look at natural phenomena. It is a resource that encourages children to create hypotheses, while not even being aware that they are doing so, to look up in class the next day and say, "Hey, I've heard about this," and perk up. For science's sake, the afterschool program staff needs to be recognized and developed as the vital support they are for science education.

Are We Alone? Transforming "Astrobiology" for Use in After School Programs

Daniel Barstow, Director, Center for Earth and Space Science Education, TERC

How do you take an activity designed for the classroom and make it work after school? The day-school and afterschool worlds are very different. You can't expect classroom learning activities to work after school without rethinking the goals, methods and target population. So, here is a five-step process to work the magic of transformation. NASA has recently funded TERC to revise an astrobiology program developed for schools and test it in several afterschool programs in the greater Boston area (and eventually elsewhere). Every project is unique, but we can use our plans for adapting the astrobiology curriculum, to illustrate the general principles. We'll pretend that you're a curriculum developer on our team who needs to take an existing day school program and convert it to work after school. Ready? Let's go.

Phase I – Embrace the Topic

First you need a passion for the topic. If you don't have it, your students won't. So, this one's easy. Astrobiology is way cool! We're talking about understanding life in the universe—are we alone, how does life emerge and develop, where do we look for it, and how do we recognize it when we see it. We begin with life on Earth and then think about other worlds—Mars, the moons of Jupiter and beyond. This is a terrific topic because the questions are deep, accessible and endlessly fascinating.

NASA defines the cutting edge of this research, in so many ways: studying life in hydrothermal vents, deep caves and deserts to understand the range of habitable places on Earth (life is amazingly versatile); sending rovers to search for evidence of water on Mars; using powerful telescopes to search for planets around other stars (planets are quite pervasive); and using radio telescopes to detect possible signals from intelligent life. These efforts move astrobiology from the realm of fantasy to one of the most exciting frontiers of science.

For science education, astrobiology is very powerful. Children are very curious about life in the universe. Astrobiology also provides a great context for integrating biology, astronomy, Earth science, chemistry, physics and engineering. Students must link understandings in these fields to make sense of the myriad questions, most of which lack answers! Isn't that what science is about? Science is not a one way of delivery of knowledge from scientists to learners (though such knowledge is important), but a questioning attitude—a sense of mystery about the world(s) around us, and intellectual tools for pursuing answers. We don't know if there ever was life on Mars, but with NASA's Mars explorations, we follow along as the rovers and orbital spacecraft find evidence of ancient riverbeds. Is there water under the surface and might it harbor life? This is "inquiry-based learning" at its best. We ask personally meaningful questions and experience the joy of inquiry, exploration and

discovery. So if you feel excitement about the topic, you're ready to dive into the work.

Phase II – Understand Your Starting Point

To transform a curriculum unit for use after school, you need to understand its current structure, learning goals and the audience for whom it was designed.

In our example, we have in place a set of Astrobiology learning activities for upper elementary, middle and high school classes, developed with funding from the NASA Astrobiology Institute and the NSF. The Astrobiology Educators Guide is distributed free of charge by NASA (nai.arc.nasa.gov/teachers/index.cfm#erg). It has been tested in classes and reviewed for scientific accuracy (fair warning: in a dynamic field like astrobiology, a printed guide is never truly up-to-date). The Guide has five activities:

1. What is life? – compare living and non-living objects and think about what life is.
2. What does life need? – grow organisms in differing environments and identify common requirements.
3. What makes a world inhabitable? – use "habitability cards" describing several planets and moons, and identify top candidates as habitable worlds.
4. What can life tolerate? – learn about "extremophiles" to understand the wide range of habitable environments on Earth, and refine the list of candidate habitable worlds.
5. Is there life on other worlds? – Since we don't know for sure, estimate the likelihood based on eight criteria ("Drake equation").

Let's consider the original target audience. We'll envision a seventh grade integrated science class in a diverse urban neighborhood. The students are typical with a mix of youthful energy and budding skepticism. The teacher has a big challenge—covering a wide range of science topics defined in the state and district science standards—and she needs to help her students develop scientific habits of mind. She wants them to engage in science questions, think through problem-solving strategies, collect and make sense of relevant data, and interpret the evidence. Her textbook basically covers the mandated topics and skills, but the integration of the sciences doesn't quite work. Students do a week of batteries and bulbs, and then examine leaves with a microscope. Yes, the students do physics and biology, but it's not really integrated.

So she tries Astrobiology because it covers several mandated topics (features of living things, water as universal solvent, planets of the solar system). Her students' interest in "space aliens" offers a starting point, but she has to shift from science fiction to serious science inquiry early in the process. She reviews the Educator's Guide and uses her science background and her experience as a science teacher to select a sequence of activities. She guides students through the activities as a line of inquiry, with one question leading to another (How do

we identify life on Earth? How could robotic instruments search for life on other worlds?). She skips those activities that don't relate to her state and local standards, but over three weeks she works her way through the Guide, and invents a few related activities to help cover the curriculum.

A few points from this example should be noted. Although circumstances will vary, the following are reasonable assumptions about the use of Astrobiology in a formal school setting.

> The implementation is driven by state and local standards.
> The teacher is experienced and trained in science education. She knows how to adapt the Guide to match her specific students. She also can create new activities.
> The students expect a lesson. They're in the period assigned to science and they expect to do a learning activity, with content knowledge that will likely be tested.
> The Guide is written for a broad range of grade levels. The teacher selects and adapts activities to match the students' varied expertise and experience.
> The science class meets five times a week. There is a continuity and momentum that can build up with this frequency of classes.
> Participation is mandatory. Students are required to attend.

By the way, the principal or science supervisor might not be quite so enthusiastic about this teacher using Astrobiology. The administrator might feel it is too far from the mainstream, or that it wastes time on frivolous topics or doesn't directly cover the mandated content. The fact that the teacher believes in it and that students are intellectually engaged might not be enough to win over the administration.

Phase III – Understand the Target Afterschool Program(s)

Now let's shift our perspective. Let's look at the afterschool world. What do we know about the needs, interests, goals and priorities of the afterschool staff and students who will use the Educators Guide? Here the challenge is the wide diversity of possible contexts, such as:

> a community-based program run by a neighborhood services center, with a wide range of academic, social, sports, and nutritional services;
> an extended-day program serving afterschool students in the same school they attend during the day, with some of the same teachers;
> a museum or nature center providing services for students who sign up for specific afterschool activities;
> or a specialized tutoring program focused on raising school grades or test scores.

They vary considerably in terms of the interests and motivations of the students, the program goals, staff experience and level of professional development, and the role of science in the program. It's tough to prepare an educational activity for all contexts, so we'll pick one as a target.

Let's say we're working with an inner city, community-based, afterschool program. In our hypothetical but typical example, the community-based program has partnered with a local nature center. Three days per week, a nature center staff person goes to the afterschool program to do some hands-on science activities. The topics stimulate and respond to student interests in the natural world—especially in city parks, arboreta and short-distance field trips.

Whereas the learning goals in the formal context are to convey standards-based content and thinking skills, in the afterschool context, they are more flexible. We want to excite students about science, about the wonders of life around them. We want to stimulate their curiosity, and help them develop skills of inquiry, exploration and analysis.

Yes, we also want to develop these skills, attitudes and content knowledge in the formal school environment, but schools do this in context of more tightly defined curriculum priorities. Afterschool programs tend to have more freedom in their selection of activities and are more driven by engaging students in interesting activities than in conveying specific standards-based content knowledge.

So, we will shift our Astrobiology curriculum a bit. While the overall structure will remain the same, we will focus more on sparking student interests and have more flexibility in the pathway through the activities.

In our example, the staff person from the nearby nature center is probably not a trained teacher, but will likely understand some of the basic biology concepts that are covered in these activities, and will likely have experience leading engaging hands-on science activities. Assuming this level of understanding simplifies our task.

If the program lacks a knowledgeable support person, we would need development activities to help the afterschool staff learn more about the content and methods of the astrobiology unit…but professional development is a whole separate topic.

Phase IV – Revise the Unit for the Target Audience

In looking at this Guide, the target audience and the capabilities of the staff, I judged that we don't need to redo the guide itself. Rather, we need to provide a better context for launching and navigating through it.

Add a launching activity: While the core question of life on other worlds is fascinating, we need to begin with an attention-getting activity to pique student interest. This is the hardest part to nail down because it depends on the

students, the preceding activities and even on current and cultural events. For example, some of the students might just have seen the newest "Star Wars" movie, or a mission to Mars might have just landed, or maybe some students asked whether the teacher thinks "space aliens" exist.

Whatever the spark, it should lead to a discussion about whether life exists on other worlds. This may start as fantastical speculation, but it eventually needs to shift to taking the question(s) seriously – What is life? What conditions support life on Earth? What other worlds might have similar conditions? How can we detect life elsewhere?

In the launching activity, we want to ensure that the students own the question—that they are curious about the topic and want to learn more. This unit is not a simple sequence of tasks. It is a response to student interests. It provides students with an enabling set of understandings and skills to pursue their personal interests in the topic.

Flow through the activities as a line of inquiry: We now can proceed with the activities in the Guide. They should feel like a science investigation—not as a set of tasks, but a line of inquiry with one question leading to another. The whole experience should be grounded in the underlying question about life on other worlds. For example, to design a strategy to search for life on other worlds, we need a clearer understanding of life (or at least life on Earth), and on what conditions make an environment habitable. Hence the activities on habitability and extremophiles are especially useful.

Make connections: As we proceed through the activities in the Guide, we need to keep making connections back to the driving questions and to other experiences in the students' lives. For example, in the Guide's first activity, students think about "what is life" by comparing a variety of living and non-living objects. Since, in our example, a nature center person leads the activity, he or she can make a wealth of connections to other experiences students have had at the center, exploring life and nature.

NASA is a powerful context for finding connections. If Mars rovers are in the news, investigate how the rovers search for evidence of water on Mars. If the International Space Station is in the news, students can investigate ISS experiments on life in micro-gravity. If NASA scientists have found another extra-solar planet, students can better understand the prevalence of planets outside our solar system.

A few web searches or phone calls can identify other resources. A scientist at a nearby NASA center or university might be conducting research on astrobiology. A parent or teacher might have a telescope with which students can view Mars, Jupiter or Venus. NASA Astrobiology Institute (nai.arc.nasa.gov) offers a wealth of information; much of it designed for the general public.

Keep the topic alive throughout the year: If we succeed in sparking their interest, then students will continue learning, exploring and monitoring the field

beyond the end of the unit. There are often news stories about life in extreme environments on Earth, or progress reports on planetary missions, or discoveries with the Hubble Space Telescope. The teacher or the students should pay attention to such stories throughout the year.

In summary, we kept the core activities in the existing Astrobiology curriculum guide, but changed the flow and context in three ways: 1) we started with a new launching activity to spark student interest; 2) we focused more on the line of inquiry and keeping students engaged; 3) we made stronger connections to astrobiology in the news and help interested students pursue the topic further. While these would also be laudable goals for a school-day activity, afterschool programs often provide more freedom to pursue this approach. In fact, since afterschool programs tend to be volitional learning (that is, students and/or their parents choose to participate), there is special need for making sure that students find personal interest, enjoyment and value in the activities.

Phase V – Refine Based on Experience

These revision sound fine, but will they work in practice? Over years of developing hands-on, inquiry-based science learning experiences, I have found that the most valuable insights come from the field tests. What really happens in the classrooms with teachers and students? After we write the revisions (as described above), we will work with teachers in several afterschool programs and see how it goes. We have a lot to learn.

The afterschool world is a wonderful place to excite children about science. And we think that astrobiology is a great context for doing that. Science is driven by deep and powerful questions. For children and adults, it's hard to find a better question than "Is there life beyond our home planet Earth?"

Our Wish List: What We Would Like to See in a NASA Afterschool Science Program

Tom Bromage, Felicia Cherry, Jessica Diaz, Adam Liebowitz, Arlene Mbonu, Jacqueline Torres
Compiled and recorded by Kathryn Venzor and Gretchen Walker, American Museum of Natural History

At the end of the demonstration site program that informed NASA and Afterschool Programs: Connecting to the Future*, the AMNH staff sat down with participating afterschool instructors and talked with them about what they would like to see in future NASA afterschool programs. This essay presents their answers to the question "What would an ideal NASA afterschool science program in our centers be like?"*

We want afterschool science to be designed for fun

Afterschool needs to be different from the school day. It's the end of the day, and children's concentration and motivation are waning. Afterschool is a place where children should be able to be children, as well as get the academic and social support they need. Our participants vote with their feet, so activities need to motivate them to come back and participate again. Activity designs that can make things fun can include:

> **Mission simulation projects**: We would like to see long-term projects that bring the participants back each week, such as a mission to Mars simulation where the participants start with research and planning, the logistics of building a space craft, and then simulate heading to the planet, carrying out the mission, and solving problems as new challenges come up.
>
> **Experiments:** We would like to do large-scale experiments, the bigger the better. For example, we would like cratering activities that involve dropping things off the roof of our clubhouse, or erosion activities that involve large sandboxes. We would like to do things recognizable to our participants as "science," such as experiments that involve chemicals and goggles that capture the feeling of old chemistry sets. We would like to connect our participants to real things whenever possible.
>
> **Games:** Our participants love trivia and other games on any topic. Any curriculum for afterschool should include games with questions about the content.
>
> **Technology:** Computer interactives and video have the power to catch our participants' attention, and as long as they are not the only elements in a program (our computer facilities are variable and must be available for use by a variety of programs in our centers), can add to the attraction for our participants.
>
> **Connections to other young people:** We like activities that bring our participants in contact with other afterschool participants, both in our own clubhouse and in other afterschool

programs. The chance to come together and engage in debates or mission simulations or activities with young people from other programs gives our participants a chance to meet and learn from new people outside their neighborhood. Sharing what we have learned with other participants, parents, and community members is an important part of our programming.

We want afterschool science to connect our participants to the world

Afterschool should be about getting outside of our buildings and neighborhoods, and understanding how what we learn fits into the larger world. Afterschool programs can connect to that world through:

Field trips: Local field trips to planetariums and museums are a standby of our programming. We can imagine trips further away, taking our participants to a shuttle take off or landing, or to an astronaut training facility. We would love to find a way for our participants to experience a simulation of zero-gravity.
Visitors: Visitors are always a great motivator for our participants. We would like to have scientists and astronauts visit our programs, or hold a large scale event to which we could bring our participants together with other programs.
Physical NASA artifacts: NASA has cool stuff that no one else has. We would like to be able to have our participants see a space suit, or moon rocks up close and in person.

We want afterschool science that meets our participants' interests and needs

Our participants have a lot of interest in and questions about science, but often have very little science learning experience. Afterschool science programs can build on their interests and meet their needs by:

Starting with basics: If we are going to do a program about a new NASA mission, like the Mars missions, we need a starting place from which to build. Our participants need to start with the broad context, and then move into specific areas of focus. We would like to see space science activities that start with stargazing activities, or learning the basics about the solar system.   We would like to see activities that help our participants build the vocabulary they need to talk about NASA science.
Exploring a variety of topics: Our participants are interested in lots of things — space, electricity, magnets, plants, animals, earthquakes, volcanoes and more. Learning about one thing sparks questions about related topics. When our participants learn about one planet, they suddenly have questions about all the planets. We would like a program that didn't limit us to a narrow range of science topics.

We want afterschool science that works with our programs interests and needs

Our programs would like to include science among our other offerings, but we do have other goals and funding issues. Afterschool science programs can build on our programs interests and needs by:

> **Supplementing our limited resources:** Our program budgets are low, and our staff members have very little time for preparation or tracking down inexpensive sources of supplies. Additional funds, inexpensive materials, or free supplies are a must for anything we are doing ourselves. Help in collecting all the supplies needed for a curriculum can make all the difference in helping us implement it.
>
> **Providing extras for program participants:** Our participants love anything they can wear that identifies them as participantsin a special program. Our participants would love to have T-shirts, lab coats, hats, or even armbands that identified them as participants in a NASA afterschool program.
>
> **Designing curriculum to work with our schedule:** Our ideal curriculum unit length is one 45-minute session a week, for six weeks. This allows us to fold science learning into the other programs we do and get through entire units without being interrupted by too many special performances or holiday parties.
>
> **Provide us with assessment tools:** We need to be able to gauge our participants' progress and share that progress with parents and our funders. We would like to see afterschool curriculum include tools for assessing participant learning, without being like the tests that participants take in schools.

There is a place for science in afterschool

We feel that the science learning opportunities are valuable for our participants. We would like the opportunity to engage in more science learning and call upon agencies like NASA to participate in the design and support of programs that interest our participants and meet our programs needs.

From Products to Programs: Telling Stories with NASA Educational Materials

Rachel Connolly, American Museum of Natural History, NASA GSRP Fellow at Columbia University Teachers College
Minna Palaquibay, American Museum of Natural History

> *Informal education is education by opportunity and is characterized by teachable moments with relevance as a delivery vehicle. By its very nature, it is as diverse as the communities and individuals it serves. It takes on the form and structure that best suits each audience. This means that topics, materials and resources need to be very accessible, flexible and adaptable. Because informal education occurs during out-of-school time, it also needs to be entertaining and high impact. The goal is to inspire interest that motivates the learner to further exploration or engenders an understanding or appreciation of a topic that allows more informed decision-making. By acknowledging and understanding the unique nature of informal education, the most useful resources can be developed and/or leveraged to better serve the Informal Education Community.*
>
> Bringing NASA into Focus: Improving Effective Use of NASA Resources within the Informal Science Education Community. NASA NEI focus group, 2005

Educational programs are the "missions" of the informal educator. Our goal isn't to land on Mars, we are the ones who bring children along for the ride, and hopefully leave them wanting more. At the American Museum of Natural History, our programs range from large, media-heavy special events to single-visit school field trips, family workshops, teacher professional development, short and long-term afterschool programs, high school internships, and week-long adventure camps. Our "engineers", the education specialists, work with one pool of NASA EPO raw materials (i.e. the curricula, activities, media, visualizations, etc.) and weave them into this wide variety of educational programming. The programs and audiences may vary widely, but the goal of telling a story of exploration and discovery is the universal thread that ties them all together. NASA materials do not come "flight-ready", and the challenge for informal educators is to merge the various elements into an educationally sound, inspiring program that tells the story and science that is at the heart of the mission. This also involves having to fill in gaps where the materials are lacking, with either original materials or other sources.

Not unlike a set of blocks, you can build anything you want to with NASA's educational materials. But the difference between what a child and an architect can do with those blocks becomes apparent when you experience the final

product. What follows are some useful techniques for utilizing NASA educational materials throughout the range of informal science programs.

Some people collect books or rocks; we collect NASA EPO materials. The planning stage for any new program includes digging through our collection of folders, posters, and curricula packets to mine them for activities and novel demonstrations. Although the materials come from missions that span the universe, we find that many of the activities they contain are not universal. Most NASA curricula materials are written for the formal setting, the school classroom. Afterschool and other informal settings are faced with different time constraints, multi-age audiences, limited materials, and different goals. These differences call for different levels of modification before the resources can become an effective element of a successful program.

Successful Informal Programming – What is it?

We have found with experience that characteristics of successful informal programs include the following elements:

The Big Picture in Context - The ultimate goal is to de-mystify some of the behind-the-scenes science that goes on in a mission, giving a child access to how we come to know what we know. We highlight what pieces of the science impact the child and are cognitively appropriate to them. Finally, we keep in mind appropriate developmental stages, in process skills as well as pedagogy.

Hands-on, Minds-on activities: Whenever possible, we include an activity that gets children's hands on a tool or on an experiment of some kind. These don't have to be expensive or complex to be very effective. A small water tank glove-box allows children to train just like the astronauts and to experience conditions similar to microgravity. A bottle of yeast, sugar and water can become different "alien" colonies that can be tested for the effects of light, heat, and many other variables. If an element of the experience is reproducible at home for further exploration, it will allow for a value-added continuity.

Continuing Exploration: We include a scientific or intellectual tool or technique for students to take home to continue their exploration. Programs are viewed as the beginning of many things: a relationship, discovery, or a support in their scientific development. We hope to supply some motivation for young people to stay in the STEM pipeline and grow in their "science-selves." These tools can be a simple as a single UV Detecting Bead, directions for making an Alka-Seltzer rocket, or an image of a Martian landscape taken by the MER rover.

Question time: Allowing time for questions to percolate, and being able to handle a high volume of them, is always a challenge, especially when the program leader is faced with questions they can't answer. Often, empowering the educator with a few phrases to replace, "I don't know," builds their self-efficacy and comfort level. Favorites include, "That's a good question, let's find out!" "Where do you think we should start?" And, "Let's put it in your question book."

The last phrase cites a tool that we have found especially useful in our afterschool programs. A "question book" can take the form of a book or piece of paper that each child has, or a "Question Parking Lot" on the board or the wall. It serves many functions, primarily allowing for the program leader to move on in the program without leaving questions behind. This pedagogical tool allows for less verbal children to have a place to express themselves. It gives the program leader a window into the children's thoughts that you can browse at your leisure after the program session is over. And finally, you are able to address the questions during the next program session, or you can write replies in the students' books. We have found this resource invaluable on many levels, and the children take great pride in their books.

Print and web site resources: These developmentally appropriate and vetted lists offer places where families can continue exploring the topic(s) from the program.

Overall flow: With all of these different elements, we unite these various elements together to create a story with a coherent flow. We keep in mind that cognitive research shows that 7 to 10 minutes is the maximum amount of time to allow before you should get your hands on something or move on to a new program element. Longer than that and you saturate people's memory, their attention begins to wander, and you can undo what you are working to accomplish. Therefore, program elements are planned in 15-minute chunks, with as little lecture and slide show as possible.

The Raw Materials: NASA educational products and how we use them

Video elements: Short video elements can be very useful, especially if they show behind-the-scenes views, a launch, or other key moments in a mission. We choose short clips, edit them together, and use them as reference throughout the program. No talking heads or interviews, we find that the same discussions could happen with the program leader or among the children themselves. Examples of successful elements that we have used include Saturday Science elements [NASA Space Station Science http://www.nasa.gov/mission_pages/station/science/index.html], scientists at work, astronauts and play, and the Toys in Space footage.

Web sites: These have the dual benefit of showing current images and news from a mission, as well as empowering children to learn where they can find the same information themselves on the Internet. We always start at the top level of a Web site and show them how to get where they are going. We include any sites that we use during the course of a program on the take-home handout. Some particularly useful NASA Web sites include solarsystem.nasa.gov, NASA Brain Bites http://www.nasa.gov/vision/space/livinginspace/10feb_brainbites.html, spaceflight.nasa.gov, http://www.NASAexplores.com, Astrobiology in your Classroom http://www.nai.arc.nasa.gov/teachers, Planet Quest

http://planetquest.jpl.nasa.gov/planetHunters/hunters_index.html,
http://TeachSpaceScience.org , http://WebofLife.ksc.nasa.gov and
www.NASA.gov .

Visualizations: These allow children to actually see what a mission hopes to do, or what it might be like to visit an alien world, giving them access to otherwise abstract ideas. A recent example of a visualization that we used often in our programming is the Dan Maas animation of the Mars MER rovers.

Activities: Understanding the role of models, both virtual and physical, is a goal of our programs. We choose science investigation over arts and craft activities, and we do not use worksheets, mazes, and word games. The more open-ended and like true science investigations that we can make the activities, the more interested and excited the children get.

Connecting to Science and Scientists

Our informal learning experiences are intended to give children opportunities to "apprentice" with real science and scientists that are both practical and developmentally appropriate. That connection can come through the activity structure, the tools used, the questions addressed, video and Internet examples accessed, and even direct interactions with scientists.

Giving children access to science increases the likelihood that they will decide they want to be a scientist.   If they do not have access and exposure to it at a young age, they will never be aware of science as a career option. One reason why so many children express a desire to be athletes and entertainers when you ask them what they want to do when they grow-up is that they have such early access to these careers in action; they can simply turn on the radio and sing along with their favorite group, or play baseball with their friends. Give them a taste of the excitement of doing science and following their own questions and passions and they will come back for more.

Reaching Out: A Call for Community Engagement

By Dishon Mills, Boston Public Schools, After-school Programs

The National Aeronautics and Space Administration (NASA) has long supported the education of children and youth with innovative projects and curricula. While historically focused on formal educational settings, NASA is now poised to make a significant contribution to the afterschool sector. Even though NASA has made their resources available to out-of-school time programs, the agency now seeks to have an intentional focus on afterschool because of the distinctiveness of the industry. This marks an important shift for both NASA as an organization and the afterschool field in general. NASA is one of many major scientific institutions that now recognize afterschool programs as places where learning in science can flourish. The *Connecting to the Future* report exemplifies how afterschool programs are beginning to be viewed as delivery points of critical content knowledge and skills in their own right, not solely safe havens for "at risk" youth when not in school.

NASA apsires to help "inspire the next generation of explorers". The *Connecting to the Future* report suggests encouraging children to make a personal connection to science through a system of engagement, capacity, and continuity.[i] While NASA will undoubtedly experience success in this endeavor, despite its best efforts, many children will be much harder to positively affect than others. Generally speaking, the underrepresentation of women, people of color[j], and people with disabilities in science careers and degree programs (collectively referred to in this essay as underrepresented groups or communities) indicates the inability of the science world to effectively engage these communities through traditional methods. In order to reach all children, NASA needs to commit to working in collaboration with underrepresented communities to best meet their needs. The purpose of this essay is to briefly present the importance of community engagement to the success of future NASA work with the afterschool sector.

What is Community Engagement?

The term "community engagement" is often overused and misapplied, therefore, it would be valuable at this time to clarify what is meant. "Loosely defined, community engagement is the process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest, or similar situations to address issues affecting the well-being of those people. [k]" In initiatives that seek to impact children from various backgrounds in afterschool

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[i] Walker, Gretchen, Wahl E., Rivas L. *NASA and Afterschool Programs: Connecting to the Future*. March 2005.

[j] i.e. Blacks, Native Americans, Latinos, Pacific Islanders

[k] Fawcett SB, Paine-Andrews A, Francisco VT, Schultz JA, Richter KP, Lewis RK, Williams EL, Harris KJ, Berkley JY, Fisher JL, Lopez CM. Using empowerment theory in collaborative partnership for community health and development. *American Journal of Community Psychology* 1995;23 (5):677-697.

programs, including children belonging to underrepresented groups, community engagement must not be viewed as simply a programmatic embellishment to generate "buy-in," but rather a critical success factor to ensure that the mission of the program is fulfilled. It is not an effort that is done for a finite period of time, but rather a partnership that is cultivated and maintained over the life of the initiative. From the perspective of organizations like NASA, the process of community engagement involves:

> Adopting community engagement as a critical success factor;
> Identifying the community(ies) to target based on the mission of the organization and available resources;
> Making a long-term commitment to invest in a targeted community(ies);
> Instituting a process to engage the community in a dialogue;
> Developing goals, vision, and an implementation plan for the project in collaboration with the community;
> Outlining the roles and responsibilities of both the agency and the community;
> Creating a mechanism for continuous information sharing and community input.

Need for Community Engagement

There are several reasons that necessitate true engagement of members of underrepresented communities.[l] This essay will discuss three of these reasons. Firstly, many individuals within underrepresented communities, especially people of color, distrust government. A recent study conducted by National Public Radio, the Henry J. Kaiser Family Foundation, and Harvard University's Kennedy School of Government looked at Americans' distrust of government.[m] Their findings indicate that African-Americans distrust government to a much greater extent than their White counterparts.

As a result of this distrust, many in underrepresented groups may not expect NASA to work with them long enough to make a true impact, and, as a result, would rather employ a more community-based strategy than get involved with a federal initiative.

Secondly, for some, especially the disenfranchised, NASA is as removed from their communities as the stars it studies. Women, people of color, and individuals with disabilities face formidable challenges in society today. They may need to be convinced that an agency like NASA can truly comprehend those challenges and actually be committed to finding solutions. In other words, underrepresented community members may not immediately see the relevance of NASA to their lives and situations. To them the Administration may

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[l] Communities are heterogeneous and dynamic, and it is not the intention of this essay to oversimplify very complex social issues or to imply that all members of a certain group are monolithic in their beliefs, actions, or situations.

[m] "Americans Distrust Government, But Want It to Do More." July 29, 2000.
http://www.npr.org/programs/specials/poll/govt/summary.html

appear as part of an impenetrable bureaucracy that is either unwilling or unable to hear their voice.

Finally, many in the science community view the field as apolitical, ethnically neutral, and gender neutral. While this is what science should be, throughout this country's history, communities have been wrongfully abused and subjugated in the name of science. Incidents like the Tuskegee syphilis study and recent comments by Lawrence Summers regarding women in the sciences pollute the virtue of the discipline, making it harder for underrepresented groups to see science as something for them. While individual initiatives like those featured in *Connecting to the Future* can partially counteract some negative perceptions of science, a more comprehensive approach is needed to transform members of underrepresented communities into self-described scientists and explorers.

Given these and other barriers, conventional methods of content delivery (e.g. internet-based resources, project-based curriculum, camps, etc.) will only have marginal success in underrepresented communities. A system of long-term community engagement is, therefore, the only viable method of overcoming these barriers. By partnering with local informal science institutions familiar to the community and giving the community a role in the design, implementation, and oversight of afterschool initiatives, NASA will not only demonstrate its commitment to reach underrepresented communities, but will also foster community ownership and investment in the initiative. Once this takes place, NASA will cease to be the outsider trying to come in. It will become part of the community. While this process is not easy and requires time and effort, it promises to enable NASA to "go beyond its four walls" and into underrepresented communities.

Conclusion

NASA is uniquely positioned to bring inspiration to children everywhere. The Administration embodies determination and kindles the imagination. NASA gives us hope, and that hope has the power to transform lives and communities. It is for that reason that NASA must do everything it can to ensure that all children have access to that hope. A NASA Afterschool Initiative has the potential to help children see a future for themselves that they would not have otherwise dreamed. A commitment to community engagement through partnerships with local and regional intermediaries will ensure that the future NASA hopes to inspire includes children from all communities.

How can NASA work with, listen to, and learn from existing afterschool networks?

By Shari Asplund, Co-chair of the Science Mission Directorate's Community-Based Organizations Working Group

There are many ways and many levels to work with existing afterschool networks. It can range from simply making available resources known to the community, to offering workshops at conferences, to the dedicated mutual commitment established with the Girls Scouts of the USA. A sustained effort requires funding, time and a commitment.

Afterschool is a challenging environment for NASA to work with due to its great diversity but it has great potential that can make it a win-win relationship for both. There is a greater chance for success if we work with programs that have the interest and capacity to use the materials, offer planned, supervised activities that focus on academics, have trained staff and have regular attendance by the learners. Another challenge for afterschool is balancing the reality that students need homework help with the opportunity to present activities that enhance and support classroom learning. By working with and listening to the afterschool community, NASA can support their efforts to meet the needs of their participants and inspire the next generation of explorers.

Recommendations for NASA to Broaden Participation in Afterschool

The **Community-Based Organizations Working Group** (CBOWG) was formed in early 2002 as one of many working groups established by the NASA Office of Space Science (now the Science Mission Directorate (SMD)) to explore areas of interest to the Support Network of educational forums and regional brokers. The CBOWG members, representing the forums, brokers, NASA programs and missions, met regularly via telecons to determine what their focus would be within this large sector. After doing some research, the group chose to focus on afterschool programs. That led to a meeting with leaders from the National Institute on Out-of-School Time (NIOST) and participation in the National Afterschool Association (NAA) annual conference. Through those two actions, and a variety of follow-up efforts, the CBOWG has taken a lead role in learning about the world of afterschool and how NASA can be a part of it.

Each CBOWG member has shown considerable interest in developing the relationship with afterschool and has participated in the working group in addition to their normal job responsibilities. Since the CBOWG was formed, the NASA Education Office has added an Informal Education component. The CBOWG has worked with and has offered assistance to this office. The CBOWG should continue its efforts to further the links between NASA and afterschool. The group should consider the results of the AMNH study and, working with the Informal Education office, decide on future directions and

establish realistic goals that they can achieve with limited time and no additional funding.

To educate NASA staff about the afterschool community the CBOWG could consider: 1) generating a **brochure** to give the NASA E/PO community information about afterschool programs and suggestions for working with them, including them in mission proposals, and what to look for in finding local or regional programs to link with; 2) conducting **workshops** at conferences attended by NASA E/PO personnel (such as the one scheduled for the September 2005 meeting of the Astronomical Society of the Pacific on Education and Public Outreach entitled: Working with After-school and Youth Programs) to introduce the topic and provide useful suggestions for working with afterschool; 3) making the CBOWG **web site** a resource for NASA E/PO personnel to find information and research links for afterschool; 4) providing wide dissemination of the final version of the AMNH project on afterschool.

The **Promising Practices in Afterschool (PPAS)** web site (http://www.afterschool.org/) is an effort to find and share things that are working in afterschool programs. It is for afterschool program directors who want to improve the quality of their programs but also useful for program staff, volunteers, parents, community members, policymakers, funders, researchers, and others who care about children and youth. The CBOWG could undertake an effort to learn more about the PPAS listserv and consider using it to send monthly suggestions to the afterschool community, such as providing information about the NASA Educator Resource Centers, featuring specific Web sites like Space Place, highlighting a current mission, and providing an activity. In turn, we could ask the community for suggestions on ways their needs could be met and how NASA could meet them, thus establishing a structure for two-way communication.

Jim Stofan, manager of NASA's Informal Education Office, participated in the **Coalition for Science Afterschool** conference that convened in January 2004 in Santa Fe, New Mexico. He, along with educational leaders from STEM education and afterschool staff explored emerging trends in youth development and science learning. A follow-up meeting was held in January 2005 in Los Angeles. A Steering Committee is working to continue the efforts begun at the meetings. NASA should stay informed and involved with the progress this group makes as it moves forward in the five-year plan that was created.

The seven **SMD regional Broker/Facilitators** can be proactive in finding afterschool programs in their regions that are interested in incorporating NASA content and working with staff to conduct training on activities. Many of the brokers already work with afterschool entities. They could also explore contacting NAA state affiliates and community-based organizations such as 4-H, Girls Inc., Girl Scouts, and Boys and Girls Clubs of America. They can share with the community what they learn.

The **Forums** hold annual community conferences and sometimes convene advisory committees to help guide their planning efforts. They could invite

afterschool representatives to the annual conferences to introduce them to the community and to facilitate discussions on potential collaborations. The Forums could invite afterschool representatives to participate on advisory committees as part of the informal education segment. The Solar System Forum at JPL could host a seminar for E/PO and research staff to present the AMNH study results and other research to encourage wider use of NASA activities in afterschool.

Some mission E/PO partners have established relationships with afterschool organizations. **McREL** in Denver, Colorado, and the National Partnership for Quality Afterschool Learning are co-hosting a conference in June 2005 called The PEAK Afterschool Conference (Practices that Engage and Attract Children). These partners can educate the NASA E/PO community about their efforts through the Forum's monthly telecons or annual community conference.

The JPL Education Office discovered the **Collaborative After School Project** (CASP) and hosted a half-day visit in May 2005 for 65 leaders representing CASP sites in the Los Angeles area. The visit included a tour of the Lab to motivate them about the work being done at JPL, and presentations on the NASA educational resources available to them. CASP provides training, technical assistance, and resource development for after school programs in California. A follow-up session is planned for January 2006 to evaluate the use of the NASA education materials distributed. A meeting with 70 additional leaders is scheduled in September. Those at other NASA centers could look for similar organizations funded by 21st Century Community Learning Centers and use this new relationship as a model. A tour of the facility is a great way to engage people and establish amutual ongoing relationship..

CASP also has worked with the California Department of Education to produce a series of guides for college students working in afterschool programs. NASA partners with many universities. An effort could be undertaken to find colleges studentswho work in afterschool and offer them trainings in NASA activities. They could then provide feedback to NASA on their experiences and needs.

Thoughts on following up *NASA and Afterschool Programs: Connecting to the Future*

How can we make NASA resources that are relevant to the afterschool community accessible to them? Below are some thoughts and suggestions related to the recommendations in *NASA and Afterschool Programs: Connecting to the Future.*

Recommendation 1: Make NASA resources fully accessible to the afterschool community

Create an Afterschool Area on the Education section of the NASA Solar System Web site (solarsystem.nasa.gov) and/or on the NASA Portal under Informal Education. Having one dedicated area for NASA materials that are appropriate for afterschool programs (organized by project, activity, topic, and grade level) will make it easy for them to find and use the resources. It could provide links to

mission and other NASA Web sites where additional activities can be found. One section could be created to serve other groups, such those working in camps and outdoor education. It would show the afterschool community that NASA is interested in working with them.

Ensure that NASA Educator Resource Center (ERC) materials are made available to afterschool leaders. Currently these materials are available, however this needs to be clarified across the board. NASA CORE materials now are available only to formal education teachers. This resource should also be made available to afterschool leaders. The NASA Aerospace Education Services Program (AESP) is a nationwide, free program for teachers, students, and the general public. This program should also be made available to afterschool programs.

NASA materials can help afterschool programs create an environment that is conducive to science learning by allowing the staff and participantsto celebrate science on their walls and ceilings with engaging posters, 3-D models, displays of the solar system, andprojects made from activities. NASA materials can provide opportunities for scientific discussions and debate. NASA activities can make science real for learners. Materials that feature NASA "spin-offs" can be the engaging factor that will get children interested and realize that what NASA does is relevant to their lives.

NASA could redirect some existing formal classroom programs and resources to afterschool programs that offer the opportunity for academic achievement and youth development by aligning academic content with ways of learning that can engage students and help develop social skills and self-identity. Research shows that there is great synergy between the goals of youth development and inquiry-based science, especially hands-on science and math. Activitiesdone in afterschool could link to what students are learning in the classroom, but would offer greater freedom and a broader focus.

Afterschool leaders have a wide range of knowledge and experience. NASA materials and curricula may not be easily usable by those who lack extensive science or math background and have little preparation time. Offering training through a variety of venues to make them comfortable and familiar with the materials would go a long way toward their actually using them.

A packaged program of science activities for elementary and secondary afterschool programs may fill a need and make it easier for leaders to use materials. The curriculum used by AMNH in their study could be used as a pilot program. Military bases have huge numbers of high quality afterschool programs that are accredited by the National Afterschool Association, but to date, efforts to explore adding NASA materials to their programs have been unsuccessful.. Military contacts indicated they are looking for "programs" and may be more open to working with NASA if packaged activities are supplied.

The Solar System Educators could be trained as to what materials would be appropriate for the afterschool setting and could then design a program for training afterschool leaders.

NASA Centers that work with student programs such as FIRST robotics and the Student Launch Initiative should be encouraged to include afterschool in these programs. Additionalcosts might be involved, but that could offer an opportunity for them to learn about fundraising.

Recommendation 2: Extract and concentrate on the NASA content that is most appropriate for afterschool science

The programs and missions could identify existing products and activities that they feel are especially appropriate for use in afterschool programs. If funding were available, a team could be put in place to work with afterschool curriculum specialists to review the materials and identify adaptations needed to make the curriculum more afterschool-friendly.

E/PO specialists who write mission proposals can include specific education opportunities and activities for afterschool programs. McREL recently added such segment to the Genesis mission web site called Community Quest, designed with afterschool in mind:
http://genesismission.jpl.nasa.gov/product/community/scout_overview.html

Afterschool Astronomy Clubs have everything a program needs to get started. Programs designed for afterschool clubs such as these would also work well for outdoor education programs and camps.
http://www.afterschoolastronomy.org/runningaclub/grants.html

NASA Centers could work with afterschool programs to host a science fair where children could display the projects made using NASA activities, particularly those that are project-based.

Recommendation 3: Partner, tap into existing networks, use intermediaries and science-rich institutions.

Each NASA Center has a relationship with the NASA Explorer Schools. These schools may offer afterschool programs that would present further opportunities for using NASA materials in a unique way. For example:

> Extend the Girl Scout model to other organizations, especially those that already partner with GSUSA.Some of the Solar System Ambassadors might be interested in giving presentations to afterschool programs thatofferhands-on activities.

The NASA programs/missions that funded the Museum Alliance (Mars, Cassini, Deep Impact) could authorize the program coordinator to assess existing relationships between these museums and afterschool programs and explore the possibilities for future partnerships.

Explore the American Camp Association to find out if there is interest to include NASA activities in their programs.

Connecting to the Future

Afterschool science programs can reinforce what children and youth learn in school and can play a part in preparing them for future success by helping to foster critical thinking, reasoning, and problem solving skills, thus setting them on a course for lifelong achievement. Time spent in science learning activities after school can enhance participants' self confidence, boost their grades in science, help them apply science concepts to their own lives, and kindle interest in science careers. Partnerships between NASA and the afterschool community offer the opportunity to impact participants' interests, skills, and belief in their own ability to do science.

The NASA-GSUSA Collaboration: Together We Inspire Young Women to Explore, Discover, Understand

Leslie Lowes, Rosalie Betrue, Jet Propulsion Lab
Jaclyn Allen, Kay Tobola, Johnson Space Center
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NASA's relationship with the Girl Scouts of the USA (GSUSA) provides an opportunity to offer engaging experiences "as only NASA can" for the nation's largest underutilized population in science, technology, engineering, and mathematics (STEM) careers— women and girls. Together, we embrace the notion that girls' participation in STEM is vital in strengthening the economy and ensuring a more diverse, dynamic, and productive workforce for the future.

A Partnership Based on Strong Mutual Needs

NASA's Education Strategy seeks to improve the public's understanding and appreciation of science and broaden participation in the STEM workforce. GSUSA seeks to inspire girls with the highest ideals of character, conduct, patriotism, and service as they are engaged in core program areas — including STEM — that support their development as informed and resourceful citizens. Mutually, both organizations also focus on better engaging underserved populations, including girls in public housing, bi-lingual communities, rural communities, and those with special needs.

This resonance in the organizations' focus is matched by a shared approach to education. Both NASA and GSUSA understand that emotional responses to learning are important, and that positive learning experiences involve engaging learning activities, comfortable environments, and opportunities to build personal communities. Both are committed to giving girls life changing experiences, providing opportunities for them to grow as people and as scientists, and helping them obtain the skills necessary to succeed in STEM and in life.

A Relationship Built and Sustained Collaboratively

Initiated in 2001 by NASA's Science Mission Directorate (SMD) Education and Public Outreach program, the NASA-GSUSA relationship has developed collaboratively over a period of several years. We identified mutual needs and took time to learn about each other's culture and audiences. We utilized one of our NASA team member's experiences in Girl Scouts as a girl, leader, national trainer, board member, and designer of science programs for camps. Focusing on earth and space science content, we began with smaller pilot efforts, at both the national and local level, and have continued to improve and grow our program as we learn from past experience. This work culminated in a Memorandum of Understanding (MOU) between NASA/JPL (who manages the effort) and GSUSA in 2003. To facilitate the expansion to other NASA content, an agency-wide MOU was signed in 2005. We capitalized on each

organization's strengths, resources, and existing structures, and clearly identified our goals, objectives, and respective roles.

NASA–GSUSA relationship goals

Raise the comprehension and interest of girls and women in science-related topics

Encourage girls and women to pursue careers in science, technology, engineering, and mathematics (STEM)

NASA–GSUSA relationship objectives

Provide Professional Development to the adult membership to improve their ability to understand and communicate NASA-related STEM concepts

Provide Program Experiences for girls, adults, and families to enhance their understanding and appreciation of NASA-related STEM topics and careers

Communicate to raise awareness and encourage participation in the program

Evaluate the program impact and use assessment and evaluation studies to improve the quality of the program

Contributions from Girl Scouts of the USA

Girl Scouts of the USA is the world's preeminent national girl-serving organization, with 2.9 million girls and 986,000 adult members, and has served over 50 million girls and young women since 1911. With national coordination, GSUSA National Headquarters works with 315 autonomously chartered councils to provide training, funding support, program opportunities, and expansive research in core program areas. Providing a formal structure for access to girl and adult members, and expertise that promotes positive youth development for girls are GSUSA's key contributions to the relationship.

GSUSA offers a **variety of delivery systems** through which Girl Scout programs are offered. These delivery systems include workshops, day and residential camps, special events, interest groups, mentoring projects, career days, and the more traditional troop, groups, and badge and patch programs.

A central piece of the Girl Scout structure is its **professional development program**, for both paid council and camp staff, and adult volunteer leadership. Quality training supports the achievement of council and national goals. Councils train their volunteer trainers in topics that include adult and girl learning styles, social, emotional, physical and cognitive developmental principles, successful training designs, volunteer and membership recruitment, program management, and group management techniques. Additionally, GSUSA provides "Train the Trainer" workshops where the volunteers hone their skills, develop new content materials, and receive updated program information. Once trained, adult council representatives are expected to **make a commitment to return to their respective**

councils and implement training and related events for adults and girls.

The relationship with NASA is a key component of GSUSA's national Girls Go Tech initiative. GSUSA **provides encouragement and support to its membership for participation** in programs under this STEM initiative. Broad dissemination of program and training opportunities is accomplished through its *Leader* magazine (circulation of almost 1 million adults), internal On-line Council Network Web site, and tri-annual regional and national leadership conferences. Impassioned participants, particularly trained adult members, give voice in their local councils to the benefits and impact of the program. GSUSA leverages other programs and funds within the initiative to support, for example, 70-90% of membership travel costs for national trainings held at the GSUSA Edith Macy Conference Center in Briarcliff Manor, NY.

Providing quality youth development programs for girls, and supporting continuous improvement and measuring impact are core to GSUSA's program philosophy. GSUSA has a National Advisory Committee of older Girl Scout members from across the country to inform national program staff on primary girl interests, issues, career concerns, and "what works" for girls in STEM and other program areas. Access to the Girl Scout Research Institute, formed in 2000, provides youth development knowledge about girls through core program areas that include STEM programs, as well as a synthesis of cutting edge research that exists on the healthy development of girls.

Contributions from NASA

NASA provides connections to exciting content and applications of STEM and experiences of the commitment and passion of NASA people for their work. The intrinsic excitement of space exploration, and NASA's quest to answer compelling questions such as "Where do we come from? Where are we going? Are we alone?" can be used to develop and feed a sense of wonder in the girls and adult participants.

The most appropriate resources to provide an understanding of and sustained access to NASA STEM content are drawn from the wealth of existing NASA earth and space science education programs, many of which were developed initially for use with other audiences.

Using cultural knowledge of GSUSA, NASA provides **content training expertise and selection of educationally sound experiential activities**. We offer national, regional, and local training workshops through the GSUSA professional development system. They vary in length from several hours to several days.

Their design is based on experiential learning for audiences with a wide range of science backgrounds, diverse motivations for participation, and widely varying levels of comfort with STEM. Key components of the design and activity selection include: content that is thematically designed around science topics, fun, active learning, and confidence-building experiences; presence of NASA scientists and engineers who humanize the content; ownership of the experience by the trainers through activities that ask for predictions; creative applications of new information; and reflection and sharing of personal observations and growth.

Events include **interdisciplinary programs** for girls to build their capacity to like and understand science. *Imagine Mars* is a web-based initiative for youth project teams to explore their own community, and interact with scientists, engineers, architects, artists, and community leaders to understand the different planetary environment on Mars. The *Solar System Community Event kit* helps engage underrepresented residents of rural and urban areas through hands-on science activities, display materials, and logistical handbook for hosting an event.

Proactive connectivity to **NASA networks** is made through programs such as the *Night Sky Network* of trained amateur astronomy clubs, the *Solar System Ambassadors* volunteer public outreach program, and the SMD regional broker/facilitators.

NASA's on-going process of discovery provides opportunities for authentic learning experiences using real-world applications of STEM. This can help girls to see how fundamental principles of STEM can be applied to solve the complex problems of exploration, and build their capacity to join the STEM workforce.

"Citizen science" programs offer adults and youth a way to contribute scientific results using actual mission data or data they collect themselves. Learners contribute measurements of atmospheres/climate, soils, hydrology, and land-cover/biology to the project-based GLOBE program. **Student investigator** programs provide youth opportunities to work directly with NASA data. Girls use NASA data and make direct observations to understand the prediction of solar storms through the Student Observing Network "Tracking a Solar Storm" module.

Work experiences at NASA facilities are the culminating experience for older girls who have an interest in STEM as a career. Girls are encouraged to participate in existing internship programs at NASA centers, such as SHARP (Summer High School Apprenticeship Research Program).

Quality contact with committed, passionate, and accessible NASA people offers a personal connection to science,

exploration as human endeavors, and a better understanding of the careers involved. Scientists and engineers who are skilled at communicating in informal learning settings are a valuable resource for contributing to the excitement of exploration and discovery. They share information about their science or career, serve as expert resources, and act as mentors. They serve as accessible role models – many, in fact, come from Girl Scouting (including two-thirds of women astronauts).

Working Together

In partnership, both organizations support a core group of highly trained staff and volunteers, identify and develop a thematic program structure and individual events that involve girls in NASA content, and evaluate for continuous improvement and impact.

Key to the continuity of the program is our investment in a core group of highly trained Girl Scout staff and volunteers. Approximately 50 staff members and volunteers are knowledgeable about the NASA earth and space science content and message, supported by NASA SMD and by the NASA Explorer Institute program (GSUSA NASA Experience: A Vision for Girls in Earth and Space Science, JPL D31428 (2005)). They have grown into a strong community, helping each other with materials, event ideas, and moral support. A key motivating factor for their full participation is a demonstrated long-term commitment by both organizations.

> NASA monitors, mentors, and nurtures them by providing access to further content information and expertise, assistance in planning and designing content for events, and, when possible, validation and excitement at local and regional events through a physical presence. We maintain an internal Web site for collection of event data, resources for events, a message board, and a calendar of future events and workshops. Our public Web site http://solarsystem.nasa.gov/girlscouts hosts articles on NASA women in STEM careers, highlights of past events, and links to mission information and children-friendly Web sites.

> GSUSA acknowledges and supports their development as core trainers in STEM representing their respective councils and GSUSA, and promotes their extended utilization as peer mentors and providers of technical assistance to other councils engaged in STEM programming. The trainers also bring their experience and expertise to broader regional trainings, special STEM events for girls, NASA exhibits at the GSUSA national convention, and serving in an advisory capacity on advanced STEM funded initiatives.

We develop pilot events that promote collaborations with local science-rich organizations. The University of California, Riverside Science and Engineering Day was a Solar System Community Event attended by over 1000 children and their families. The collaboration between UCR, JPL, the local Girl Scout council, and student members of the Society of Women Engineers allowed us to build an event large enough to support high interest, and to provide participants connections to local resources.

To provide for continuity, we build thematic, connected program structures around unique NASA content. The aim of such programs is for girls to become informed and independent seekers – to spark their interest and get them knowledgeable enough to pursue the topic of the theme further. Activities, events, inquiry learning experiences, and connections to related organizations and networks are woven together so that a participant moves through a developmental progression. Our first thematic program strand covers the topic of astronomy -- observing the night sky and the sun. We build a sense of wonderment through observing and questioning, then provide context through knowledge of our night sky neighborhood, and help participants think and act like scientists. We bridge from what can be directly observed to broader concepts like size and scale of the universe, and connect the need to explore beyond earth. Deep Impact Hawaii Getaway is a 9-day model destination event for high school girls surrounding the Deep Impact mission's encounter with comet Tempel-1. It connects the history of observation in the Hawaiian Islands with early Polynesian and Native American views of space to how we explore today.

We perform formative evaluation on our larger program elements, such as professional development trainings and pilot destinations, and collect anecdotal stories on their impact. We plan to provide NASA trainers feedback on which and how activities are being used in the field, and data on how many people are ultimately being affected with them. A case study on the development of the NASA-GSUSA relationship is underway by the Program Evaluation and Research Group at Lesley University.

Impact and Future Directions

Our five national trainings have reached 100 GSUSA trainers, and nine regional trainings has served over 350 people.   Our initial group of core trainers has reported 227 events directly reaching over 18,700 girls. Through such programming as space-based summer camps and science camps for at-risk youth, core trainers reported such impact as a girl influenced to be "either a geologist or the first woman on Mars." Representative comments from trainers include: "NASA training really fired me up to be a better science teacher…and enjoy exploring and experimenting with my students;" "gaining courage to take a chemistry course;" and event organizers reporting troop leaders that "couldn't stop talking about the change in the girls' interest in science."

We look forward to broadening and understanding the impact of our programs. (The extent to which we can do this will be funding-dependent.) Broadening the

relationship to other NASA content requires professional development education within the agency on the approaches we use and on GSUSA's expertise in girl development, along with integration of the lessons learned from other NASA center/GSUSA council programs. We can create and build more thematic strand programs and pilot the use of technology to attract a broader demographic of participants. We can build more continuity in the program through stronger connections to GSUSA Girls Go Tech and NASA pipeline programs, and will strengthen our focus on careers and use of role models. We will strive to obtain support for the study of a longer-term impact of the relationship.