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 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 posits 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 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.

1. 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 is a leading factor 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 both develop their academic skills and 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.** The increased emphasis on accountability and testing have all those who work with young people seeking ways to support student performance and, at the same time, to give young people an opportunity to explore their own interests. As an example, 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

- **Afterschool programs make a difference in the lives of their participants.** Research shows that participant 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 center's mandate. Missions within the Science Mission Directorate are required to have a unique E/PO program. In addition, NASA has targeted both the formal and informal science education communities through education and public outreach programs.

In recent years, NASA has expanded its work with the informal education community. NASA education and public outreach staff have been working with museums and planetaria, and are regular presenters at the annual conference of the Association of Science-Technology Centers (ASTC). Work out of the Science Mission Directorate resulted in a "Memorandum of Understanding" with Girl Scouts of the USA. In 2002, the SMD charged a CBO (community-based organization) Working Group, comprised of experts in NASA education, to identify national partners among major youth organizations. At the same time, the 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 Office of Informal Education at 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 enhance 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)

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

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 can 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 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 young people.

Confluence: NASA and Afterschool

The interests of NASA and afterschool programs merge in three key, interrelated ways, 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 looked at science as an infinitely human and personal endeavor. NASA's educational content is awe-inspiring, its actual facilities can wow 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 critical to learning provides** a foundation and sets a tone for collaborations between NASA and the afterschool community. NASA engages young people—fires their imagination and inspires their interest etc. Afterschool also seeks to engage etc. NASA and afterschool programs therefore can work together to influence participants' attitudes about science and their ability to do science. They can help more underrepresented and underserved young people to say:

  I like science.
  I understand science.
  I can do science.
  I want to do more 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). Individuals 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 are outcomes that can **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 the 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.

2. 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 your 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 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

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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.

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 also 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, support, 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 forms 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 be packed up or conducted in the community or the field.

- **Independent community-based programs**: Care for school-age children is one component of programming offered by community-based organizations that provide multiple services to a local community, often 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. Afterschool programs sponsored by these organizations seek to meet immediate needs identified by the community, such as the development of literacy skills, and promote the development of young people as contributors to their community.

- **School-based programs:** A growing model for afterschool programs partners community-based organizations with schools to provide high-quality, large-scale, low-cost programs on school grounds, which 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 and support 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, Afterschool Matters in Chicago, LA's BEST, and New Jersey After Three 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 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 also 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, among other titles. In this report, we use the term "afterschool leader" to refer to an adult leading a group of afterschool participants. Some critical points research offers about afterschool leaders follow here.

- **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 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 have 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.
    - Local cultural or educational institutions may provide training in curricula and

pedagogy.

- National organizations may provide training in specific initiatives or core practices to local affiliates.
- Regional institutions such as the Partnership for After School Education in New York City have formed to connect afterschool leaders to professional development opportunities in their areas.
- National conferences such as the National Afterschool Association's annual conference can bring together afterschool leaders for professional development opportunities.
- 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 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) Promoted by organizations such as the Forum for Youth Investment, the positive youth development movement provided the afterschool community with definitions, skills, and success measures that 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 need to promote the participants' health and safety, and decrease confrontational peer interaction.
- **Appropriate structure**: Consistency in rules, boundaries, age-appropriate monitoring, and programming are key elements of appropriate structure.
- **Supportive relationships**: Adult leaders promote good communication and provide caring and support for all participants.
- **Opportunities to belong:** Participants are provided with meaningful opportunities for inclusion, regardless of gender, ethnicity, sexual orientation, or disabilities, and are provided with a safe space 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 are youth-centered, valuing participant input and including participants in decision making. Programs 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:** Responding to the diverse talents of participants, building on strengths, choosing appropriate materials for those strengths and talents, providing personal attention, and reaching out to the local community.
- **Knowledge-centered:** Providing a clear focus, quality content, and instruction, while also including embedded curriculum.
- **Assessment-centered:** Offering 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, sense of belonging to program and community
- **Improvement in academic performance:** Increased rates of homework completion and quality, improving grades, improvement of 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 1984, 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 a program development, evaluation, and fundraising assistance. A small number of national youth development and advocacy organizations were already engaged 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 became a major force in the development of educational policy development.** 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.
    - LA's BEST (Better Educated Students for Tomorrow) was established by the city of Los Angeles in 1988.
    - The After-School Corporation (TASC) was established in 1998 with a $125 million challenge grant from the Soros Foundation.
    - 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-eighties. 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 is 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 and facilities in many programs are at a premium.

- **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.

3. 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:

- There are existing science-rich programs with potential utility for the afterschool community at large.
- 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 primary 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 at large 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 programming 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 five- to 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 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 some schools programs use pedagogical strategies also appropriate for the out-of-school environment, they make two assumptions that can be at odds with the structure of afterschool that might require some retooling:

- Curriculum is often designed to fit into a school science curriculum, serving as a means of enrichment and drawing from concepts, examples and other knowledge established in other activities and lessons. Without that framework, it is not clear what kinds of science learning and capacity will result.

- Programs may be predicated on having teachers/leaders with formal background in science.

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

3. Distribution of programs along the developmental continuum in 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. This uneven distribution is due to the matching of content to national standards and benchmarks: The links between traditional content topics and the standards are almost exclusively at the middle and high school levels. However, there are also standards and benchmarks for understandings about science as a human endeavor, inquiry and scientific habits of mind, and the connections between science and technology. Curriculum and programs could be designed for elementary school learners that use active NASA missions and research to reach these standards and benchmarks, which are often neglected during the school day.

Among the materials designed for middle school learners, over half centered around hands on activities or data collection experiences readily adapted to younger audiences. In these materials,

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.

the “middle school-ness” is a matter of language used to discuss activities, and the depth of understanding. The activities, however, center on observation and explorations (as opposed to complex mathematical calculations) and can be adapted for younger learners. For examples of middle school activities adapted for younger learners, see the prototype curriculum packets produced for by this project.

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

Not surprisingly, 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.

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

- **Activity-based Programs**: Participants take part in group learning activities, designed to develop understanding of specific science content, and wrapping up within a single learning period (an hour, an afternoon, etc.)
- **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 below 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 or material 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 scan	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. As a result, and adults who are graduate students or teachers may be better matches for these needs.

Supports and Infrastructure: The design of program supports and infrastructure are crucial to quality program implementation.

- **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 are usually 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:

- 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.

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

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

- 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 strengthen 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 needs to 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, curricula 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.

4. 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 curriculum 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 instruction 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 and provided some interesting insights that suggest promising directions for future research and development in afterschool program design. These insights are outlined in the lessons learned listed below.

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?" "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

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

Site/leader: Unaffiliated CBO, 17-year-old leader
Age range of participants: 9- and10-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.

suspected that was primarily because they were encouraged to talk. One of the seventeen-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 participant to articulation of 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; 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 phenomenon 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 seventeen-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.

5. 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. A partnership between NASA and the afterschool community will require sustained engagement and collaboration for the long term. Making NASA educational resources – content, materials, people, facilities – is important and necessary, but not sufficient. Attention must be paid to building capacity and infrastructure as well dissemination and evaluation. Training, supplies, planning time, piloting and refining new initiatives, 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 relationships and a presence, in which NASA and the afterschool community can together develop, test, evaluate, modify and refine, within which there can be growing mutual understanding and embracing of capacities and purposes. This will all take commitment, time and money.

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 USA and 4-H and 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, scientific works in progress. 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 organization, institution, or current infrastructure 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. Pay particular attention 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.
Make long term arrangements with national and regional afterschool organizations to update content and curriculum materials, participate in staff training infrastructure, and lend the power

of the NASA name to efforts to get funding from other sources. This can help NASA to sustain science programming with its afterschool partners.

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, provide support for academic achievement, and extend 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 for keeping young people in the STEM pipeline 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.

References

Afterschool Alliance, (2004). *America after 3PM.* Report issued by the Afterschool Alliance in association with the JC Penny Afterschool Fund.

American Association for the Advancement of Science [AAAS] (1993). *Benchmarks for Science Literacy*. New York: Oxford University Press.

Barab, S., & Hay, K. (2001). Doing science at the elbows of experts: Issues related to the science apprenticeship camp. *Journal of Research in Science Teaching, 38,* 70-102.

Campbell, P. (1997). Utility is not enough. In Kreinberg, N., Wahl, E., eds. *Thoughts and Deeds: Equity in Mathematics and Science Education.* Washington DC: American Association for the Advancement of Science.

Campbell, P., Jolly, E., Hoey, L., & Perlman, L.K. (2002) *Upping the numbers: Using research-based decision making to increase diversity in the quantitative disciplines*. GE Foundation Report.

Clewell, B.C., & Campbell, P.B. (2002). Taking stock: Where we've been, where we are, where we're going. *Journal of Women and Minorities in Science and Engineering, 8,* 225-284

Crawford,B., Bell, R., Blair, L., & Lederman, N. (1999). *The impact of science apprenticeships on student conceptions of the nature of science and scientific inquiry.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA, March 28-31, 1999.

Davis, J., Wilson, B., & Learning Goals Working Group. (2003). *Strategies for success: Strengthening learning in out of school time.* Boston's Afterschool for All Partnership Report.

Duschl, R. (2000). Making the nature of science explicit. In R. Millar, J. Osbourne, & J. Leach (Eds.) *Improving Science Education: Contributions from Research.* Open University Press.

Edwards, R. (2004, January 7). NASA site bears Mars load. *FCW.com* Retrieved March 10, 2005 from http://www.fcw.com/fcw/articles/2004/0105/web-nasa-01-07-04.asp

Eccles, J. & Appleton Gootman, J, Eds. (2002). *Community programs to promote youth development.* Washington, D.C.: National Academy Press.

Ferreria, M. (2001). The effects of an afterschool program on middle school female students' attitudes towards science, mathematics, and engineering. *Proceedings of the Annual Meeting of the Association for the Education of Teachers of Science, 2001.*

Foster, L. (2001). *Effectiveness of mentor programs: Review of the literature from 1995 – 2000.* Sacramento: California Research Bureau.

Gallas, K. (1995). *Talking their way into science: Hearing chidlren's questions and theories, responding with currcicula*. New York: Teachers College Press.

Hall, G., Israel, L., & Shortt, J.(2004). *It's about time: A look at out-of-school time for urban teens.* National Institute on Out-of-School

Hall, G., Yohalem, N., Tolman, J., & Wilson, A. (2002). Promoting positive youth development as a support to academic achievement. Boston's Afterschool for All Partnership report.

Hammer, D. (2004). The variability of student reasoning. *The proceedings of the Enrico Fermi Summer School in Physics, Course CLVI.* Italian Physical Society.

Herrera, C., Sipe, C., & McClanahan, W. (2000). *Mentoring school-age children: Relationship development in school-based and community-based programs.* Philadelphia: Public/Private Ventures.

Hodson, D. (1988). Towards a more philosophically valid science curriculum. *Science Education, 72(1),* 19-40.

Jekielek, S., Moore, K. & Hair, E. (2002). Mentoring: A promising strategy for youth development. *Child Trends Research Brief.*

Jet Propulsion Laboratory (2005, March 7). Volunteer networks provides ring side seat for Saturn. Press release downloaded on March 11, 2005 from http://saturn.jpl.nasa.gov/news/press-release-details.cfm?newsID=550

Jolly, E., Campbell, B. & Perlman, L. (2004). *Engagement, capacity, and continuity: A trilogy for student success.* GE Foundation Report.

Kelley, J. (2000). *Developing the afterschool professional and the profession: Addressing quality and scale.* Charles Mott Foundation report.

Kleiner, B., Nolin, M.J., & Chapman, C. (2004). *Before- and after-school care, programs, and activities of children in kindergarten through eighth grade: 2001.* National Center for Educational Statistics, US Dept. of Education.

Kuhn, D. (1989). Children as intuitive scientists. *Psychological Review, 96,* 674-689.

McComb, E.M, & Scott-Little, C. (2003). *Afterschool programs: Evaluations and outcomes.* SERVE research report.

McLaughlin, M.W. (2000). *Community counts: How youth organizations matter for youth development.* Public Education Network monograph

Miller,B. (2003). *Critical hours: Afterschool programs and educational success.* Nellie Mae Education Foundation Report.

National Catholic Reporter (2003). As quoted in *Afterschool Alliance issue overview*, retrieved March 11, 2005 from http://www.afterschoolalliance.org/after_over.cfm

National Aeronautics and Space Administration [NASA] (2003). *Education Enterprise Strategy.* Washington, D.C.: NASA.

National Aeronautics and Space Administration [NASA] (2004). *NASA Explorer Institute Cooperative Agreement Notice Summary, CAN NNHO4ZN1001C.* Washington, D.C.: NASA.

National Aeronautics and Space Administration [NASA] (2005). *The new age of exploration: NASA's direction for 2005 and beyond.* Washington, D.C.: NASA.

National Center for Education Statistics [NCES] (2002). *The nation's report card 2000: Science highlights.* Washington, D.C.: U.S. Department of Education.

National Research Council [NRC] (1996) *National Science Education Standards.* Washington, D.C.: National Academy Press.

National Research Council [NRC] (2000) *Inquiry in the national science education standards.* Washington, D.C.: National Academy Press.

National Science Foundation [NSF] (1991). *Diversity in Biological Research.* Washington, D.C.: National Science Foundation.

Northwest Regional Education Lab [NREL] (1997). *Science and mathematics for all: It's just good teaching.* Washington D.C.: Department of Education.

Rosebery, A., Warren, B., & Conant, F. (1992). *Appropriating scientific discourse: Findings from language minority classrooms.* Cambridge, MA: TERC.

Schneps, M. & Sadler, P. (1987). *A private universe* (Video). Cambridge, MA: Harvard Smithsonian Center for Astrophysics.

Seidel, S. ,Aryeh, L., Steinberg, A. (2002). *Project-based and experiential learning in after-school programming.* Boston's Afterschool Science for All report

Selby, C. (2003). *Science: From myths to realities* or *Diverse scientists: Unified inquiry.* Unpublished manuscript

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 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. 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 bring 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 run 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 prgoram. 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 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 provided with science journals to record their experiences throughout the project. Also, 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.

- **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 not only served to understand how the curriculum was being implemented but also provided opportunities to receive 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

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

	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 that 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 learning 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 lead 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 resource and the kinds of research projects that can be conducted with that 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 place 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/supervisior *Support structure:* Selects participants, makes job assignments, provides training *Target Age:* High school, college

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 included 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
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

Program	Managing Institution	A	P	M/I
The GLOBE Program	University Corporation for Atmospheric Research/ Colorado State University		X	
Goldstone Apple Valley Radio Telescope Program	NASA, Jet Propulsion Laboatory, 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 Investigative Learning Experiences (SMILE)	Oregon State University		X	X
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	Stratospheric Aerosol and Gas Experiment III (SAGE		X	

Program	Managing Institution	A	P	M/I
(SOLAR)	III)			
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 Children Museums	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		
Exciting Girls, Minorities, and Rural Youth About Engineering	Ohio State University Research University	X		
Explore It! Science Investigations in Out of School Programs	Educational 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		

Program	Managing Institution	A	P	M/I
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	CNUY Queensborough Community College	X		
Science & Everyday Experiences (SEE) Initiative	Delta Research & Educational Foundation	X		
Science Education Resouce Center	Morehouse School of Medicine	X		
Science Quest	Educational Development Center		X	
Science Technology Education Program (STEP) Up for Youth	California State University, Los Angeles	X		
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 curriculum 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: Curriculum 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
NASA Center Web Page					
Air is Something	X	X			X

Title	K-2	3-5	6-8	9-12	S
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 Site		X	X	X	X

Title	K-2	3-5	6-8	9-12	S
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***