INSPIRE RECOMMENDATIONS FROM RESEARCH AND PROMISING PRACTICES

Brenda J. Turnbull
Marjorie D. Cohen
Jennifer C. Johnson
Molissa H. Farber

Delivered to:

Steven H. Chance
INSPIRE Project Manager
Kennedy Space Center
National Aeronautics and Space Administration

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Policy Studies Associates, Inc.
1718 Connecticut Avenue, NW, Suite 400
Washington, DC 20009
(202) 939-9780
www.policystudies.com

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Executive Summary

For the National Aeronautics and Space Administration's (NASA's) Interdisciplinary National Science Program Incorporating Research and Education Experiences (INSPIRE), this report offers design recommendations based on a review of research literature; focus groups conducted for NASA with students, parents, and educators; and the best practices of comparable projects and programs. INSPIRE, which will serve students beginning in grade 9 up to rising first-year college students, will address the following outcomes:

- Increased student interest in science, technology, engineering, and mathematics (STEM)
- Increased student knowledge about careers in STEM
- Level of student interest in science and technology careers
- Level of student learning about science and technology
- Family participants' increased interest in their student's STEM coursework

The need for the INSPIRE project is demonstrated by the macro trends in education. National data demonstrate that students from underserved and underrepresented groups currently have unequal chances of succeeding at advanced levels in the STEM disciplines, whether in postsecondary or secondary education. This means that individuals have unequal chances of gaining the credentials needed for rewarding STEM careers, and that the nation is missing out on the potential contributions of many talented young people.

The following recommendations—several of which have already informed design decisions for INSPIRE—are discussed in detail in this report:

- Use "near-peer" mentoring for academic benefits and positive youth development
- Ensure that the mentoring component has careful design and implementation, including training for the mentors
- Create a community of practice with peers, both to help students make progress in academic learning and also as a way of modeling the attitudes and behaviors conducive to later success in school and careers
- Enlist families in supporting students' academic achievement, suggesting specific actions that they can take as advocates and coaches for their children
- Carefully design a family engagement component that will work well for family members who are not themselves highly educated, and with flexibility in schedule and location

- Offer opportunities for students—particularly those from low-income families, students of color, and girls—to explore careers and envision themselves in a wide range of science and technology careers

- Work to counter the stereotypes that may discourage students from interest in science and technology careers

- Design hands-on experiences for participants, but do not expect that a set of hands-on activities constitutes a complete curriculum

- Use technology to allow participation by students who live far from a NASA center, and as a vehicle for an active learning experience for participants

- Engage community organizations to extend the reach of INSPIRE, and combine the use of technology with the use of community-based partnerships

- Reach out to early adolescents, who are at a crucial age for developing career expectations and for selecting the academic paths that lead to postsecondary success in scientific and technical fields

- By requiring presentations and written reports, give participants an opportunity to develop skills that are important for later academic success

- Organize the summer activities for older participants on a residential basis, both to broaden access to the project and also to provide a more intense and effective experience

- Anticipate potential problems with residential programming in order to address them

- Provide stipends for older participants, so that they do not have to forgo INSPIRE participation in order to earn money in summer jobs

- In engaging NASA employees and any other professionals as mentors, build in the features of program structure and training that have been found effective in other mentoring programs

- For evaluation, begin with descriptive data and formative feedback on outputs and outcomes, while establishing the groundwork and expectations for longitudinal tracking of participants. Continue to measure and report outcomes. Eventually, consider the use of a randomized controlled trial to demonstrate project effectiveness.

Introduction: The INSPIRE Project and This Study

The National Aeronautics and Space Administration (NASA) is initiating a project designed to engage and retain a diverse group of precollege students in experiences that will support their academic progress in science, technology, engineering, and mathematics (STEM) disciplines, their preparation for STEM careers, and their interest and knowledge related to careers in the aeronautics and space industries.

For this project, called Interdisciplinary National Science Program Incorporating Research and Education Experiences (INSPIRE), Policy Studies Associates (PSA) has offered design recommendations based on a review of research literature; focus groups conducted for NASA with students, parents, and educators; and the best practices of comparable projects and programs. From July through September 2007, PSA has gathered information and provided advice to NASA, informing adjustments to the evolving INSPIRE design. Our methods are described in an appendix. This report summarizes the evidence supporting the current INSPIRE plan, as well as offering further advice for project implementation and evaluation.

The basic INSPIRE framework includes participants in grades 9-12 and rising first-year college students. It has the following tiers:

- Tier 1 "Explorers" will be 9th and 10th graders from all over the country, for whom NASA will offer project activities for both students and families, largely through technology and local organizational partnerships, in out-of-school time during the school year. The students will participate in outreach and mentoring for local middle-school students.

- Tier 2 includes two summer offerings: the "Collegiate Experience" for rising 11th graders and the "High School Internship for rising 12th graders. Selection for both will be competitive. The Collegiate Experience will be a two-week on-campus program at a NASA-sponsored University Research Center. In the High School Internship, participants will receive stipends, lodging, meals, and transportation for a six-week internship at a NASA center.

- Tier 3 "Collegiate Interns" will participate in an eight-week summer internship at a NASA field installation after 12th grade and before they matriculate at college

Outcomes Expected from INSPIRE

INSPIRE is designed to achieve the outcomes identified for NASA's K-12 education programs. They are the following:

- Increased student interest in STEM

- Increased student knowledge about careers in STEM

- Level of student interest in science and technology careers
- Level of student learning about science and technology
- Family participants' increased interest in their student's STEM coursework

In our review of research and practice, we have sought effective ways of achieving these outcomes. Ideally, a comparative analysis of the results of different project design choices would have informed this analysis. However, a robust base of rigorous evaluation does not exist in the literature on out-of-school STEM programs or in the records of individual programs. Only some of the programs have been evaluated, and often the evaluations are limited to gathering feedback from participants and, in some cases, tracking their short-term educational progress. These studies do not permit cross-program comparisons because the program purposes, participants, contexts, and evaluation methods are different across programs. In some cases evaluations have compared participants with other demographically comparable students, but such designs do not prove that the program caused the results, because they do not take into account the likelihood that volunteers selected for program participation differ systematically from their peers (U.S. Department of Education, May 2007).

Our recommendations, therefore, draw upon the available evidence about promising ways of achieving NASA's intended outcomes. We recommend project approaches that are consistent with (1) the research on students' interest and learning related to STEM subjects and careers; and (2) what managers have learned from operating programs that address outcomes like those expected from INSPIRE. We cite design features that are supported by the research, and we recommend ways of implementing those features that are likely to work well, based on the experience of similar projects and programs.

The Need for the Project

National data point to disparities in attainment and participation by race, ethnicity, and gender. The disparities are particularly acute with regard to the kinds of advanced STEM coursework needed for aeronautics and space careers. The data show continuing shortfalls in participation by African American and Hispanic youth in advanced high school courses, and limited access of these students—as well as students from lower socioeconomic levels—to opportunities designed for the gifted at all educational levels.

The creation of INSPIRE reflects long-term concerns about the educational pipeline that prepares highly skilled U.S. students to excel in the kinds of work that NASA does. The National Research Council Committee on Meeting the Workforce Needs for the National Vision for Space Exploration has specifically charged NASA with attending to the postsecondary preparation of its future workforce, saying:

> The committee believes that training students to design and build satellites and satellite instruments, gain hands-on experience with the unique demands of satellite and

> spacecraft systems environments and operations, and acquire early knowledge of systems engineering techniques is an extremely important investment for NASA to make. (p. 3)

Arguably, the effectiveness of an investment in postsecondary education depends upon the existence of an adequate and adequately diverse pool of students who come out of high school with the skills and interests to take advantage of such training.

Data from many sources provide details about the nature and scope of the pipeline problem. A first question to ask is: are there enough graduates? The data do not show a pervasive or continuous problem of undersupply. However, they show that the overall completion of bachelor's degrees in STEM fields fluctuates over time (Snyder et al., 2007):

- Bachelor's degrees in engineering and engineering technology declined 7 percent between 1994-95 and 1999-2000, but then rose 9 percent between 1999-2000 and 2004-05

- The number of math degrees declined 15 percent between 1994-95 and 1999-2000, then rose 26 percent between 1999-2000 and 2004-05

- From 1991 to 2003, the total number of engineering degrees granted grew 12 percent. The number of science degrees increased by 23 percent.

But the number of degrees and the rate of increase may not be enough to meet the demands of international competitiveness. Comparative international statistics reported by the Organisation for Economic Cooperation and Development (2006) indicate that from 1998 to 2003 the U.S. had less than a 1 percent average annual increase in the percentage of its bachelors' degrees that were in science and technology, a rate of increase that was less than in Canada, Finland, Australia, or Korea. The percentage of students completing doctorates in science and technology declined over the same period in the U.S.

Whatever the severity of the problem in overall supply may be at a particular time, the important and troubling fact is that the demographic profile of students attaining degrees does not match that of the nation. In particular, the most rapidly growing groups in the population are underrepresented in STEM degree attainment. For example, the National Science Foundation provides the following statistics about postsecondary degree completion:

- In 2004, Whites accounted for 67.8 percent of all bachelor's degrees in science and engineering (S&E). Asian/Pacific Islanders represented 9.5 percent, African Americans 8.8 percent, Hispanics 7.6 percent, American Indian/Alaska Natives 0.7 percent, and Other 5.6 percent.

- Whites accounted for 65.3 percent of all S&E master's degrees. Atmospheric sciences had the highest percentage of Whites (88.9 percent).

- Asian/Pacific Islanders made up 10.3 percent of S&E master's degrees

- Blacks made up 9 percent of S&E master's degrees. They were least represented in astronomy (1 percent).

- Hispanics made up 6.1 percent of S&E master's degrees, including just 1.5 percent in atmospheric sciences

- American Indian/Alaska Natives accounted for 0.6 percent of S&E master's degrees.

In recent years, higher proportions of high school students have completed the types of advanced courses that set them on a path toward postsecondary success (Adelman, 1999). A new transcript study from the National Center for Education Statistics (NCES) shows that the completion of precalculus or calculus tripled between 1982 and 2004 (from 10.7 percent of students to 33 percent), and that the percentage of students completing chemistry, physics, or advanced biology nearly doubled, from 35.4 percent in 1982 to 69.2 percent in 2004.

However, this NCES analysis is one of many that points to the problem of continuing disparities by race and ethnicity in high school programs. Another 2007 analysis from NCES elaborates on the racial and ethnic disparities in STEM course completion at the highest level in high schools. Its analyses reveal the following:

- 62 percent of Asian/Pacific Islander high school graduates completed calculus or another advanced math class, compared with 46 percent for White students, 29 percent for Blacks, and 28 percent for Hispanics (p. 28-29)

- 62 percent of Asian/Pacific Islanders completed advanced science or physics, compared with 46 percent for Whites, 34 percent for Blacks, and 32 percent for Hispanics (p. 29)

Some research has addressed the challenges of addressing the academic needs of intellectually talented students in underserved groups. Conventional in-school programs for gifted and talented students are more apt to reach White students and those from affluent families. Borland has noted:

> The ongoing National Educational Longitudinal Study (NELS '88) conducted by the US Department of Education (e.g., 1991) revealed that eighth grade students whose families' socio-economic status placed them in the top quartile of the population were about five times more likely to be in programs for gifted students than were students from families in the bottom quartile. (2004)

Ford and Harris (1999) contrast the participation in gifted programs by racial and ethnic group, showing that Hispanic students were under-represented by 24 percent in 1978 (that is, they constituted 6.8 percent of all students but 5.15 percent of students in gifted programs)—and that their underrepresentation had grown to 42 percent in 1992. By the same measure, the underrepresentation of African Americans in gifted programs grew from 33 percent to 41 percent.

The numbers demonstrate that students currently have unequal chances of succeeding at advanced levels in the STEM disciplines, whether in postsecondary or secondary education. This means that individuals have unequal chances of gaining the credentials needed for rewarding STEM careers, and that the nation is missing out on the potential contributions of many talented young people.

To help address these challenges, INSPIRE must find effective ways to engage and educate its participants. We begin our discussion of recommended project features with the features that are currently slated for all tiers. Next, we discuss recommendations that are more specific to Tier 1, followed by recommendations for the residential and internship experiences of Tiers 2 and 3.

Design Features of All INSPIRE Tiers

Each of the INSPIRE tiers will include mentoring by "near peers," the creation of peer learning communities among participants, enlistment of family support, early and continuing exposure to STEM career possibilities, and competition. We discuss each of these design features here, and we also recommend ways for NASA to attend to curriculum development for each INSPIRE tier.

Near-Peer Mentoring

INSPIRE will enlist its participants in mentoring. Part of what they do in INSPIRE will be to help encourage and guide students one or a few grades below them; and they will themselves be mentored by older students. This approach is well supported by literature on group work, and by data collected in focus groups and interviews with STEM programs. In the mentoring literature, peer mentoring usually refers to the broad category of mentoring programs involving youth serving youth. Recently, the terms "cross-age" or "near-peer" mentoring has been used to describe peer mentoring programs in which the peer mentor is older (by a few years or so) than the student protégé. According to the California Association of Peer Programs (2005), peer/cross-age mentoring is defined as a program in which "[s]tudents develop an encouraging and supportive relationship with other students, usually younger in age, for the primary purpose of providing broad support, guidance, and friendship."

- Use near-peer mentors, based on recent studies of mentoring that have shown promising results for those who are mentored (the protégés)

In one of the most rigorous studies to date on cross-age mentoring, Karcher, Davis, and Powell (2002) used an experimental design and a randomly assigned control group. The program was found to have had a positive effect on the proteges' connectedness to school, parents, and their sense of the future. The research team also found improvements in the academic achievement of protégés.

The likely benefits for protégés cover a wide variety of important areas in youth development and academics: connectedness to community, improvement in social skills and self-esteem, and academic achievement. These developmental relationships can touch on a broad range of factors that affect academics and career pathways, including attitude, behaviors, and goals. Peer mentors offer greater social credibility among students, especially those in the middle school grades, and are a logical element of intervention programs based on existing knowledge about the nature of peer influence (Hansen, 1998; 1996).

- Expect academic benefits for the near-peer mentors as well as the protégés.

In 2001, the California Association of Peer Programs (CAPP), a nonprofit organization, found that peer programs in California's middle and high schools had a positive impact on peer mentors and the students they served. In surveys conducted as part of the CAPP evaluation, a significant majority of school administrators and student advisors reported that peer mentors and peer protégés improved academically as a result of their involvement in the program.

In a study that focused on both the student protégés and the older student mentors (considered to be "teachers" in the program), Breakthrough Collaborative's impact on program participants was assessed via a comprehensive longitudinal study. Founded in 1978 in San Francisco, Breakthrough Collaborative is a non-profit, national organization that "increases educational opportunity for high-potential, low-income middle school student and inspires outstanding college and high school students to pursue careers in education." The study found that Breakthrough teachers were academically talented high school and college students, many of whom were former Breakthrough students. As a program that focused on underrepresented populations, Breakthrough retained alumni as teachers, creating a teaching team that looked very much like the middle school student participants: 57 percent of the teachers/mentors were of color, whereas the national average for this type of program was only 13 percent. The engagement of students as middle schoolers made their transition to teachers/mentors practically seamless and inevitable, and they were able to relate especially well to the new participants, similar to INSPIRE's model of participants at each tier mentoring down to younger, rising participants.

For students performing the mentoring-down, there is evidence to suggest that being a near-peer mentor can help participants develop deeper conceptual understanding of scientific subjects. One study found academic benefits for "advanced student mentors" in a program for minority engineering students, in which mentors interacted regularly with proteges "through tutoring and involvement in problem-solving workshops (Good, Halpin, & Halpin 1998). In another study of nontraditional college students, Lundberg (2003) found that the strongest predictor of understanding science was having had experience teaching science. The Urban Institute (2005) concludes that "the act of teaching facilitates or reinforces the learning process."

- Capitalize on young people's enthusiasm for near-peer mentoring

In focus groups conducted for NASA in summer 2007, students reported that they were interested in the idea of being a mentor and in being a leader for other students. Students reported that they liked the idea of, "giving back to other students." Educators who participated in the focus groups also said that having older students work with younger students could be an effective learning exercise for students.

In two programs from which PSA gathered data and advice, managers spoke of the rapport and enthusiasm generated by college-age mentors for precollege participants. One said:

> One of the things that has made the program successful is "near-peer mentoring". We have college undergrads teach these eighth graders. We find that the younger students relate better to students who are closer to their age and have done so much. That has been very helpful and contributed to the success of the program.

Similarly, another said:

> The middle schoolers also work with college student mentors. They really benefit from seeing the college students, they get to see these students who are older who they can aspire to be like—real women students who are studying engineering, math, computer science.

- Ensure that the mentoring component has careful design and implementation, including training for the mentors.

As found in the Youth for Youth project, successful training programs for peer mentors include substantial modeling and practice of both formal and informal interaction (McDonald, Grove, and Forum, 2000). Successful training programs also include serious consultation by peer mentors about the program goals and objectives, to ensure a clear understanding established at the outset and revisited during the training period. With well-defined training, peer mentors can develop lifelong skills. Once they learn to teach and model positive behaviors and attitudes, they may end up generalizing what they learned to new situations (Finn, 1981).

Peer Learning Environments

- Create a community of practice with peers to help students make progress in academic learning

The benefit of organizing students into learning communities is documented in the literature on classroom practice that calls upon students to work together on problems, ask

clarifying questions, and find alternate solutions (Bransford, Brown, & Cocking; Brown & Campione, 1994).

The types of communities of practice that have been instituted among college students could also potentially be emulated and adapted for high school students in INSPIRE. Research on success in undergraduate STEM programs calls attention to the benefits to achievement, attitudes, and persistence associated with participation in study groups (Springer, Stanne, & Donovan, 1999). The use of study groups has been highlighted as a technique for boosting the success of minority students (Treisman, 1992; Hrabowski, 2002). One of only three federally supported STEM programs identified by the Academic Competitiveness Council as having sound evidence of effectiveness is one that offers peer-guided small-group sessions to supplement the lectures in undergraduate chemistry classes (U.S. Department of Education, 2007).

- Also use peer mentoring as a way of modeling the attitudes and behaviors conducive to later success in school and careers

While the term "peer pressure" is often used negatively, as noted above, peers are necessary and critical in helping adolescents make successful transitions and life choices. Peers can and do act as positive role models by demonstrating appropriate social behaviors, by listening to, accepting, and understanding the frustrations, challenges and concerns associated with adolescence (Carr, 1996). Additionally, peers can support academic goals and serve as important sources of information for upward academic mobility (Stanton-Salazar, 1997). Research has found that the primary relationship in which development and socialization takes place may be with peers (Johnson and Johnson, 1987). Peer or cross-age mentoring is a way of making sure that at least some of the peer pressure high school students receive is positive in just this way.

Some program managers commented that having students work together on joint projects with culminating events or products gives precollege students a good foundation for the group work that will be expected of them in the future. In college and in their future STEM work, students should be prepared for work styles that are typical of the STEM fields, where work is seldom carried out on a solo basis but instead involves group collaboration. As one program manager described this idea: "We hear the mantra: Engineers work in teams. . . . [We want our participants to understand that] it takes different abilities to be a good communicator, a good writer, a creative brain, and working alone a students wouldn't see this." A different program manager said:

> Collaborative projects work best. We try to group students together as much as possible. So much of college work now is group work. People entering college are realizing their professors will be having them work in groups. This is important in our program from dealing with roommate issues to learning strategies. They need to learn it now if they are going to need it in college and career. We work with low-income students, and they learn to deal with others. There is some research that says taking students out of their home

environment can be good. It can help them see what is possible and get out of their patterns. So working in groups helps in working and learning with other people.

Family Support

- Enlist families in supporting students' academic achievement, suggesting specific actions that they can take as advocates and coaches for their children

INSPIRE is designed not only to instruct students but also to strengthen the supports for their continuing success in STEM. The relevant NASA outcome measure is: "Family participants will show an increased interest in their student's STEM coursework."

The literature on career aspirations recognizes the role of family members in shaping children's expectations and plans. According to Murray and Mosidi (1993, cited in Urban Institute, 2005) there is evidence that African American and Native American students are even more heavily affected by their parents' influence than their White peers. Another study of college students by Gloria and Hird (1999) showed that minority students tend to display lower levels of self-efficacy in career decision-making than their white peers. In light of these associations, the Urban Institute (2005) recommends that programs meant to encourage minority students to pursue STEM careers should make a distinct effort to involve parents.

Similarly, it is well known that students vary in the social capital that their families provide for school success. Families give their children advantages in school when they influence their choices of friends, guide their spare-time pursuits, and control their television access (Clark, 2002). A detailed study of mothers' efforts on behalf of their children's school success revealed that many of the efforts just mentioned are common across all socioeconomic levels—but also found some differences between mothers with higher or lower educational attainment (Baker & Stevenson, 1986).

The Baker and Stevenson findings point to specific actions that families should be coached and encouraged to take. The mothers with at least a college education were more familiar with specifics of their child's school performance and had more contact with teachers, equipping them to advocate on behalf of their child when difficulties arose. In addition, the college-educated mothers more often chose college-preparatory courses for their child in high school, whether or not the child had high achievement in middle school. To bolster the chances of academic success for INSPIRE participants whose parents may not have college educations, it will be helpful to coach families in using these tactics and advocating for a strong academic program for their children.

- Carefully design a family engagement component that will work well for family members who are not themselves highly educated.

Focus group data suggest that parents who may not have college educations or who may otherwise be unfamiliar with STEM content need to be supported in their efforts to reinforce and encourage their children's learning. Parents commented that they sometimes feel that they do not have the resources with which to support their children in STEM area work. INSPIRE should, they suggested, take this into account in framing ways for parents to become involved.

One program manager described the challenge of designing family coaching:

> It definitely is something we've been thinking about – how do you do that without being insulting? We want to have a certain sensitivity to different needs. One thing we've talked about is having role models who have come from having very good parental support, but whose parents didn't go to college. Then the parents can use the role model's information, [when the role model says,] "just being supportive is what my parents can do for me"

Another program manager said that program works to actively encourage parents who are not familiar with the STEM fields to become advocates for their children's STEM learning. The same program manager went on to say that parents must be equipped to support their children and that parents are really the most effective at influencing their children, even if they do not have a STEM background, themselves.

> We say, "It doesn't take a scientist or engineer to grow one." We really encourage our parents to know that they don't have to have a PhD to encourage their kids to go into STEM, but you need to have the tools to set them up for success. You need to know what kind of opportunities to expose them to. Believe it or not, every parent I know says something like, "Wow, I never knew NASA did all this, that these programs were available."

The same program manager continued:

> We design activities in which the student and family can be engaged together. We are unique in our family focus groups, where we have specific forums with families only. We bring in guest speakers to educate parents on various topics, including state proficiency testing, requirements to go to college. It's good to know when your child is in elementary school that their children should NOT skip algebra if they want to go to college. As a result, the parents feel empowered. Some of the adults are even going back to college.

Managers from STEM programs that involve parents reported in interviews that they have specifically created opportunities for parent involvement that do not intimidate parents and that help parents feel comfortable with the STEM topic:

> The whole idea of inquiry based parent-daughter workshop was that we wanted them, the adults and the girls together, to generate their own questions, we developed a structure where we gave everyone a common experience and then we would challenge them to do something, to cultivate question asking.... We wanted adults to think about themselves as collaborative, scientific learners, to explore, and to think about themselves as science learners. We picked topics like water, things where people had some knowledge, already. It was really for us to try to cultivate that partnership aspect between the girls and their adults. That seemed to even influence them at home – we heard many stories, after-the-fact, about how in regular-life situations moms and daughters were talking about the math and sciences – you know, one person talking about how they would be driving in their neighborhood and pointing out all of the triangles that they saw. Or in the shopping mall, finding themselves talking about science.

- Design family involvement that is flexible in schedule and location, recognizing that these factors may be barriers to participation.

A manager of a national program described the use of technology in engaging parents at one of the program sites:

> They send home a DVD of the program that shows what the experience is like for their kids. Parents see this and can share in it with the students. Little things like that make a difference.

Focus group data collected at the Centers suggest that parents are eager to participate in their children's STEM educational experiences. At the same time, parents reported that would be helpful if INSPIRE parent activities are organized in a manner that takes working parents' schedules and transportation concerns into account. Parents' work schedules and their obligations to care for other, younger children can sometimes make it difficult for parents to come to activities. Parents reported that having sufficient advance notice can help to alleviate some of these conflicts. Parents also said that transportation can sometimes be a problem, so that they might be most able to participate in activities that are located in their communities.

In an interview with a program manager, she explained that programs need to work with parents in order to get them involved. Programs have to communicate with parents in the communities and find out how to best facilitate parent participation.

> One of the classic things that always happens, at first, is that people come and drop their kids and leave – which absolutely does not work with this program. It takes a lot of communication to resolve this, but we are usually able to and we have to work on approaching parents in a way that helps them to understand that they are a critical piece of this experience for their daughters; it is always a challenge but we work hard on understanding where our parents are coming from so that it can happen.

Exposure to STEM Career Possibilities

- Offer opportunities for students—particularly those from low-income families, students of color, and girls—to explore careers and envision themselves in science and technology careers

Career exploration in adolescence can enable students to transcend any limits on their horizons that may come from their family backgrounds. In childhood, family members are a major influence both as role models and as sources of suggestions for career direction (research summarized by Koszalka, 2002). As children arrive at adolescence, though, opportunities for career exploration take on greater significance. Koszalka explains that the development of interest in science careers in adolescence has been shown to vary with students' view of themselves as scientists, with their perception of peers' and mentors' interests in science, their participation in science activities at home and outside school, their use of computer technology at home, and their gender.

Disparities by gender and race/ethnicity in students' interest in STEM fields and careers have been documented. In the early 1990s, eighth-grade girls were less likely to indicate interest in a mathematics- or science-related career than were boys with similar levels of achievement, attitudes toward their mathematics class, and family background. Hispanic and African American eighth graders expressed less interest in these careers than did white students (Catsambis, 1994).

Research suggests that youth base their career aspirations in part on their beliefs about their capabilities (McDonald & Jessell, 1992). Thus it is of concern that in the 1990s tenth-grade girls showed a lower self-concept with regard to their mathematics performance than boys whose mathematics achievement levels were the same. This gender disparity was most pronounced among Hispanic girls but least pronounced among African American girls (Catsambis, 1994).

It is possible that the gender differences in student beliefs reported in the 1990s have lessened in this decade, however. A national survey conducted in 2006 found that 65 percent of high school girls reported they had learned a lot in math class, statistically identical to the 66 percent of boys who said the same (Public Agenda, 2006). That survey also found that students of color were somewhat *more* likely than white students to agree that understanding science and having strong math skills before they leave high school was "absolutely essential" (53 percent for African American and Hispanic students combined, vs. 48 percent for White students).

A few studies—generally with small numbers of participants—have looked at the results of interventions designed to increase students' interest in STEM fields and careers. For example, high school girls selected for participation in a week-long summer program in the physical sciences and engineering were surveyed at the time of the program and a year later (Phillips, Barrow, & Chandrasekhar, 2002). All participants were high achievers in mathematics and science. Overall, the girls' level of career interest in these fields remained stable over that year. Selected participants whose career interest in these fields had increased markedly were interviewed. They reported the following: (1) the program had increased their confidence in

their own abilities related to the physical sciences; and (2) they remembered a specific, career-related activity in the program one year after it took place

An evaluation of a career exposure project compared students who were exposed to "career education materials and activities" to those who were not. The study found that those receiving such career exposure could not only list available careers, but could also "identify more skills they were learning that are relevant to the careers they aspired to; were more confident about acquiring a good job; and more frequently communicated with faculty, alumni, and fellow students about career decisions (Venglar, Goldberg, Cavanaugh, and Whiteneck in Urban Institute 2005).

- Provide participants with a very wide range of ideas about STEM career options.

In his review of empirical literature, Boylan (2006) notes that increased knowledge of career options can often "have the paradoxical effect of increasing student uncertainty about career plans." He goes on to explain, however, that "this uncertainty is primarily the result of much richer knowledge."

A program manager described some of her program's offerings for middle-school participants, which are intended to broaden their thinking about career options:

> We partner with Northrop Grumman and we have the students meet with representatives from there. They are not necessarily mentors, but they are people who they can look to as role models, and it is great. One person that we have come to us from there is really honest, and she tells them, "look, I was not a great math and science student in high school or college, I had to work really hard, it was not easy. I wasn't the smartest, but I thought it was interesting and fun, so I kept at it." She always asks the kids, "do you like solving puzzles?" or "do you like working with your hands?" or "do you like to make things, like collages or projects?" She asks them things that are not just, "do you like math" but instead, questions that look to get kids thinking about the types of thinking that they enjoy – things you might not expect, but that are very much related to careers and educations in STEM, so that is really great and it helps kids who do not see themselves as strong in math or science to see how maybe they really might be a good fit for those subjects.

The same interviewee continued:

> Exposure is really important here. Our girls and boys were full of ideas about careers and fields of study by the end – stuff that they had never heard of when they started with us. So, I think that getting them out into the field, and having them see places and people that represent different areas in the STEM fields is immensely important.

In another program, participants visit a variety of high-tech workplaces:

> For each program, at least one or two field trips per year. [They go to] corporate settings– Intel, Google, Pixar. We prep the girls with lists of possible questions. We

> prep the organization so we don't just go on a tour. We tell them what we want out of it, and ask if they can accommodate. This is another role model opportunity. Female employees come eat lunch with our girls. We ask that there is some hands-on component in the trip. One trip in particular, to Biolab, was very hands-on.

The same individual comments that presenting a range of career options enables participants to identify one or more that could be a good fit for their own interests:

> A lot of it is just awareness that the careers exist. That's what we hear time and time again – "I didn't know somebody did that!" It opens up their idea of what people do. The more they learn, the more they learn about their options, and they can pick something that fits their personality.

- Work to counter the stereotypes that may discourage students from interest in science and technology careers

Stereotypes can discourage students, especially students from underrepresented populations, from interest in science and technology coursework and careers. For example, in a Public Agenda survey of high school students, when shown the statement, "I'd be really unhappy if I ended up in a job or career that required doing a lot of math or science," 45 percent agreed. The rate of agreement did not differ between girls and boys.

In an NSF report (2001) that looked at the public image of the science community, the issue of stereotypes was deemed important because:

> Children are strongly influenced by the images they see around them at home, at school, and in popular culture….If they harbor negative stereotypes of scientists and engineers as nerdy and weird-looking, then they could reject science and engineering as potential careers.

Social scientists have created an assessment that specifically looks at the way children view scientists called the "Draw-a-Scientist" Test (DAST). In this assessment, students are asked to draw pictures of scientists, which are them examined for stereotypical features. NSF (2001) references Margaret Mead's 1957 observation that "[t]he scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses… He may wear a beard, may be…unkempt…. He is surrounded by equipment… and spends his days doing experiments." According to the DAST research, Mead's stereotypical image continues to live on in the minds of children. Researchers found that while this image is formed early in a child's life, in older children it is even more ingrained and pronounced (NSF 2002). Students from underrepresented groups can find it particularly difficult to identify with this stereotype and therefore may not see STEM as an attractive or viable career path.

Exposing students to STEM professionals can work to counteract these stereotypes. A program manager interviewed for this study pointed to the value of housing her program at a research hospital with working professionals of all backgrounds:

> We call our senior scientists who are here to be guest teachers or instructors. [Students] are exposed to the diverse population that works here. That's why we decided to have it at a place like [this,] so they can see how it is in a professional setting.

Another spoke of the importance of the personal stories that presenters offer when they speak to participants:

> One thing that has really helped is the personal story thing. [A recent presenter] talked about how she has two kids and goes hiking. She seems normal to them. [Presenters] are not just talking about work, but also opening up about their other side of life – how they balance professional and personal life. That's something that a lot of girls, especially if their parents are encouraging them, wonder: if they can have a family, do fun things on the weekend. Then they see that they can. That's really worked well.

Competition

- Take advantage of students' enjoyment of competition to engage them in learning and to open their eyes to a range of career possibilities

Students in the focus groups said that they enjoy competitions, such as team competition in robotics.

Interviews with program directors yielded insight into the value of involving students in competitive activities. Programs reported that competitions, especially those based around hands-on, group work were very effective means by which to engage students in learning activities.

> We do lots of hands-on activities... In the evening we do competitive activities... At night we simulate what will need to do for the Mars mission. We still work in teams but it is more competitive and fun. It is good to mix up the longer term project with short term activities. It also helps to tie activities to an interest. For example, we shoot off rockets and do the egg drop activity. These are fun activities. The competition helps build confidence. They are engaged and they compete.

Competitive activities, according to another interview respondent, also position students to explore their own interests. One project manager explained that a design competition for high schoolers had been successful in helping students to envision what they might like to explore in the future and what academic or career choices they might consider:

> At the high school level we have the design challenge, which is a competition that is focused more on doing something worthwhile. It is not simply focused on how one becomes an engineer. I recently heard from one girl who was a senior, she said that prior to participating; she was not interested in being engineer. But, she enjoyed the design challenge and how it made her feel like she could help someone, so now she wants to be

> an engineer. It [design challenge] helps for students to think about engineering as ways to help people and to help make difference. This is what can flip light switch.

Another program also commented on how competitions help students think about their futures. The interviewee said that not only are competitions and awards a good way to acknowledge students' successes, but that they are also useful in that they motivate other students to work hard:

> We recognize students when they're competing, and we give awards out for those competitions. At the end of the year, we have awards ceremonies for students who are graduating and going on to the next level, so students can see their peers being successful. They can see our high school students going to college, college [students] going to the workforce.

Curriculum Development

- Design hands-on experiences for participants.

Focus group data collected at the centers affirmed the importance of giving students the chance to participate in hands-on activities. Students reported that their favorite STEM activities have been hands-on activities that related concepts to real-life applications. Parents who participated in focus groups reported that their children do not respond well when they are only exposed to lecturing. Educators also said that hands-on learning opportunities often help students to understand the real-life relevance of their work. Further, educators commented that NASA has the advantage of being able to tie the STEM content to real-world applications, which provides students with an excellent point of entry into the STEM content.

In the interviews with program managers, they mentioned the utility of hands-on experiences in generating student interest in STEM. In describing that program's best practices in generating student interest in STEM, one manager said:

> The focus is primarily hands-on. We do not have textbooks or hand-outs or any such things. We find that the students really love that, when they can ask questions and work in small groups.

- However, do not expect that a set of hands-on activities constitutes a curriculum; the development of an effective curriculum requires care in structuring the learning opportunities.

Raizen et al. (1995) have written that "hands-on activities without minds-on engagement are merely entertaining activities for youth." They advocate activities that support critical thinking, creativity, and the systematic development of understanding.

In a similar vein is the advice about effective instruction in out-of-school time offered by McLaughlin, who advises that programs should have these characteristics:

- Youth-centered, providing personal attention and building on the strengths of participants and their communities
- Knowledge-centered, having an intentional curriculum
- Assessment-centered, not in the sense of testing but in the sense of engaging youth in cycles of planning, practice, performance, feedback, and recognition

A National Research Council committee issued recommendations in 2006 for science instruction in grades K-8, and the committee's advice about "doing science" may be applicable to INSPIRE project design. Its report advocates that students gain experience in "conducting investigations; sharing ideas with peers; specialized ways of talking and writing; mechanical, mathematical, and computer-based modeling; and development of representations of phenomena" (NRC summary, p. 4).

An interviewee describes the importance of a combination of hands-on activities with related field trips:

> Then, they must also be engaged in a hands-on portion that ties into where they are visiting. It has to be connected and that will help them to come out of the experience with a broader perspective on jobs and things that they can study.

Some interviewees cited the value of housing a program in a professional setting. One pointed to evaluation results that support this program feature:

> We do surveys when they start the program to find out if they are interested in science, what motivated them to sign up for [the program] – a lot of them say the money. We do an exit survey, and we find that they seem to have liked the ability to work in this kind of a research environment.

Another interviewee described the philosophy his program had toward hands-on activities and how participants learn best:

> We encourage all the kids in our programs to be "designers, creators, and inventors." We study how students learn through a process of designing and creating things. We study how and what they learn in the process. It's the process of designing that's most important to our work with kids in STEM programs. We tend to focus a lot on underrepresented groups – minorities, low-income kids, and girls . . . . One thing we have found in trying to reach out across [racial/gender/income] lines is that it's better to allow people to explore their interests using shared themes. Have young people build on their own interest, but as a collective whole. We might ask them to design a machine. One group that's really into entertainment or play might design a merry-go-round.

> Another group that's really into the mechanics of walking or robotics or animals might design a robotic dog that does something helpful.

He provided an example of the types of activities his program uses to carry out this philosophy:

> The Cricket technology is especially good for middle [and high] school students. They combine many different types of design activities – computational design, physical design, etc. [The youth] learn basic math and engineering concepts through their own interests. And the Cricket technology is one of the only where we've seen interest levels consistent across genders and other potential biases. Most engineering stuff is very boy-biased, but Cricket really is not, which is what makes it ideal for our purposes. We think the tools and technology we develop are incredibly important. They have to be open-ended enough to be used in many different ways.

Tier 1 Features

The current plan for Tier 1 includes all the features just discussed. In addition, the Explorers in Tier 1 will participate in INSPIRE through technology-enabled experiences at geographically dispersed locales. They are likely to work with community-based organizations with which NASA will form partnerships. Through outreach, Tier 1 will also offer a crucial bridge to the middle-school years when students form academic plans and career ambitions, and families need to advocate for their children's academic opportunities.

Use of Technology

- Use technology to allow participation by students who live far from a NASA center.

Technology, and computers particularly, can play an important role in developing creative and critical thinking skills in students, such as scientific inquiry, as evidence from education psychology suggests. For example, Roschelle et al. (2001) have viewed the potential of computer technology in terms of its support of four fundamental characteristics of effective learning: active engagement; participation in groups; frequent interaction and feedback; and connections to real-world contexts.

Technology can be an effective learning tool, especially when actually teaching students a skill or concept in the real world is too costly, time-consuming, difficult, or even dangerous (Federation of American Scientists, 2003). Students who find themselves prohibited from coming to a NASA center, because of issues like distance, transportation availability, or basic accessibility, or even students who have access to a center but would be prohibited from conducting some of the more dangerous experiments, can benefit from INSPIRE by way of distance learning technology.

Learning opportunities enabled by technology can take several forms. Students at remote locations can take part virtually in NASA events through video- or audioconferencing, or through webinars. Depending upon the aims of the event and the technology chosen, such events can include demonstrations of scientific or technical procedures, interactive presentations by individuals in STEM careers, or even technology-enabled group work by participating students.

- Use virtual distance learning as a vehicle for an active learning experience for participants.

One option for taking advantage of e-Learning technologies is in using online learning platforms such as wikis, or more complex software like Moodle. With wikis, which are collaborative websites which can be directly edited by anyone with access, instructors can post assignments (e.g., hands-on experiments or a set of websites to consult), and students can post their subsequent answers. Moodle is an "open-source" e-learning platform that can include wikis and other collaborative features. The stated philosophy of Moodle (which originally stood for Modular Object-Oriented Dynamic Learning Environment) includes both a constructivist and a social constructivist approach to education (http://docs.moodle.org/en/Philosophy). Moodle emphasizes that students – and not just teachers – can contribute to the educational experience in many ways. Various design aspects of Moodle reflect this emphasis through features such as the aforementioned wiki, peer and teacher or mentor assessment, blogs, chat forums, and contributing or commenting on entries in a database. Although Moodle's philosophy espouses a constructivist approach to learning, it is flexible enough to allow for a full range of modes of teaching, from simple delivery of content (e.g., HTML pages) or assessment.

An intriguing set of possibilities is presented by persistent immersive synthetic environments (PISE), such as Second Life, and NASA has begun to explore the educational possibilities presented by these environments (Laughlin, Roper, & Howell, 2007). As Laughlin explained in his presentation at the NASA Education Conference in August 2007, the best-known PISE currently, *Second Life,* has had "nearly 7 million registered users. This increasingly popular medium presents an enormous potential as a tool for knowledge management. Collaboration and knowledge modeling could benefit significantly from the use of immersive synthetic environments." He explained that the generations of students born since the personal computer and digital technology have become common household tools are known as "digital natives." They live in the digital world, and connecting them to mentors, scientists, and their peers through a Massively Multiplayer Online Game (MMOG) will feel familiar to them.

As Laughlin suggested in his presentation, a NASA MMOG would be an "easily accessible gateway to a NASA synthetic environment." *Second Life* is already set up to allow a secure virtual environment for INSPIRE participants and teachers. Laughlin provided examples of areas of opportunity that can be found via MMOG. In small virtual settings, students can participate in live meetings or salon discussions. In larger venues, students can view and participate in multimedia presentations. Even more specifically, an engineer or engineering student could inspect a Liquid Oxygen plant, complete with operationally realistic mockups, or could approach a spacesuit locker which has usable objects contained within. He argued that

"right now, *Second Life* is the best PISE we have for knowledge management, education, training and collaboration."

- Create a distance learning curriculum that provides students with hands-on activities.

Distance learning and the use of technology do not need to rely solely on the virtual world. By involving partner organizations with qualified staff members and providing appropriate materials, NASA can enable students to experience hands-on design and experimental activities while still keeping an all-important connection with NASA. Two programs created and run by the people who were involved with Beyond Black Boxes (the Media Lab) illustrate some of the ways a program can marry distance learning to hands-on activities.

The Playful Invention and Exploration (PIE) Network, funded by NSF, aimed to bridge the divide between the physical and the virtual. The PIE Network introduced "new technologies and activities that fluidly link the use of physical materials with digital technology in creative inquiry and inventive exploration." Originally conceived as a program for inner-city youth with few technological opportunities and even fewer opportunities to conduct serious scientific inquiry, the PIE Network consisted of two parts: activities that occurred in science museums collaborating with the PIE Network, which included annual MindFests, Make-Your-Own-Workshops, and an Exhibition Hall; and Dissemination, which consisted of several different strategies to make sure that PIE ideas and activities reach beyond the PIE museums. The latter part contains several components that might be of use in INSPIRE implementation.

One of the most useful PIE strategies is the Online PIE Idea Library. A resource created by the PIE museums, the Idea Library comprised PIE projects and stories available on the Web. The projects were designed to help people get started on playful-invention projects in homes (where students can involve their parents and/or siblings), in schools, and in community settings (often in collaboration with a partner organization). The creators of the PIE Network took advantage of the internet to provide videos of projects, search capabilities for finding projects matching personal interests, and "invention maps" showing the paths of exploration, lines of investigation, and problem-solving strategies used in the invention process. The content of the Idea Library came mostly from the PIE museums' Make-Your-Own Workshops, using various technologies such as the commercial LEGO Control Lab, the Media Lab's Design-by-Numbers software, and the Media Lab's "cricket" technology, a family of small lightweight programmable bricks that can be easily integrated into everyday objects.

Partnerships with Organizations

- Engage community organizations to extend the reach of INSPIRE.

In an essay, "Reaching Out: A Call for Community Engagement," Mills advises that "community engagement must not be viewed as simply a programmatic embellishment to

generate 'buy-in,' but rather a critical success factor to ensure that the mission of the program is fulfilled." Mills discusses several reasons for NASA to engage members of underrepresented communities, two of which are especially relevant for INSPIRE. The first is that research has shown there is distrust of the government throughout minority communities, making partnerships with established, community-based organizations a desirable feature of NASA's outreach strategy. The second reason is that underrepresented community members may not see NASA as relevant to their lives and situations, which means that NASA should foster community ownership and investment to encourage community members to consider participating.

In an essay in the same volume, "How can NASA work with, listen to, and learn from existing afterschool networks?" Asplund explains that partnering could take two forms. First, NASA could make resources and content materials available to the afterschool community (more passive role). Second, NASA could tap into existing networks, intermediaries, and science-rich institutions to deliver specific program components (more active role). INSPIRE's model would use the latter, more active role for NASA by teaming up with networks and organizations, including those with which other NASA education projects already have relationships. As an example of this potential, Asplund looks at the relationship every NASA center has with the NASA Explorer Schools. She points out that "these schools may offer afterschool programs that would present further opportunities for using NASA materials in a unique way." She goes on to suggest other examples of this active role NASA could take in partnerships:

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

In focus groups, students, parents, and teachers all commented on the potential benefits of NASA partnering with other community organizations to provide INSPIRE programming. All respondent groups said that the centers provide students with the unique opportunity to have direct access to NASA. However, adults and youth respondents said that holding satellite events in at community organizations or educational institutions would help to increase participation by facilitating access for those participants who live farther away.

During our interviews, one program manager explained how his collection of programs partnered with a wide variety of organizations to recruit participants and to use community-based centers in which to house the programs. The partner organizations were targeted based on the needs of the individual programs:

> In some programs that were more school-based, we partnered with a specific teacher who recruited the students. We've also teamed up with Citizen Schools many times and used their infrastructure to recruit kids. And with the Computer Clubhouses, many of them are located in Boys & Girls Clubs, so we will go through them to recruit participants…. We've relied pretty heavily on our partners to attract kids. And sometimes we partner with science museums, often for a one-day event or even a series of events, and they sign up the kids.

He continued, describing one way his program found to solve a vexing problem (transportation for participants) through partner funders:

> On average, we have about 20 kids per event or series or program, but it really varies with the program itself. And Computer Clubhouse is on more of a drop-in basis. And in the beginning, we actually got funding for transportation for the kids. We had a specific site we wanted to use and we were targeting kids who lived in a couple of housing projects, so we got funding from local companies and local foundations to provide transportation to and from the site.

Coordinated Use of Technology and Partnerships

- Combine the use of technology with the use of community-based partnerships, rather than viewing them as separate strategies.

As an example of the coordinated use of technology and community partnerships, we describe here the Computer Clubhouse. Organized by The Computer Museum, in collaboration with the MIT Media Laboratory and funded by the Intel Corporation, the Computer Clubhouse "is designed to provide inner-city youth with access to new technologies. But access alone is not enough . . . . It represents a new type of learning community – where young people and adult mentors work together on projects, using new technologies to explore and experiment in new ways." (Resnick et al., 1998) Many of the Computer Clubhouses are housed in Boys & Girls Clubs across the country. One of the leading tenets driving the Clubhouse project is that students become designers and creators, not just consumers, of computer-based products. The common framework of all the Clubhouse's activities is engaging youth in learning through design. The variety of activities runs the gamut from constructing and controlling LEGO robots to orchestrating virtual dancers.

In conjunction with a wide variety of activities, the Clubhouse provides a wide variety of design tools to support the activities. The tools range from introductory paint programs (such as Kid Pix) to high-end animation tools (such as Macromedia Director). The Clubhouse also provides construction kits, such as LEGO Control Lab, for creating and controlling robotic machines. Youth must engage in mathematical or scientific thinking as part of "a natural, integral part of the activity itself" when engaged in certain computer-based activities. For example, in using Programmable Bricks to build and program robots, youth consider similarities and differences between animals and machines. They discuss whether real animals have "programs" like their robots, which helps them develop intuitions about feedback.

At the Clubhouse, the computer plays a key role. The computer becomes a type of "universal machine," supporting design projects in many different domains; the Clubhouse encourages youth to engage in activities related to music, art, science, and math. While one participant is using a computer to control a robotic construction, another participant might be using the neighboring computer to create a graphic animation.

The Clubhouse uses mentors from the community to provide guidance and support to the youth as they work through the activities they are interested in. Mentors volunteer their time, and they are usually a diverse collection of experts. On any given day, participants might receive advice and direction from an engineer, a composer, or a painter. The Clubhouse encourages collaboration within its network through joint design projects using the Internet and mentors and staff members to share ideas across sites.

Outreach to Middle School Students and Families

- Work with early adolescents, who are at a crucial age for developing career expectations

Young people's interest in STEM careers may solidify at an early age. A longitudinal study of youth in the United States points to the importance of students' career expectations in eighth grade as a contributor to their eventual pursuit of a science major (Tai, Liu, Maltese, & Fan, 2006). A national sample of eighth graders was asked in the National Educational Longitudinal Study (NELS: 88) what career they expected to pursue. Those who said they expected a science or engineering career were followed through college, and turned out to be 3.4 times more likely to obtain a bachelor's degree in physical science (as opposed to a non-science field), even after controlling for the other important variables of sex; race/ethnicity; mathematics and science achievement, coursetaking, and attitudes; and parents' educational level and occupation.

- Specifically inform students and their families about selecting academic paths that lead to postsecondary success in scientific and technical fields; do not assume that they or their schools will automatically take care of their placement in challenging courses

An often-cited set of findings is drawn from NELS: 88, which asked eighth graders about their college expectations and their plans for high school coursetaking: one-half to two-thirds said they planned to complete college, but only 25 percent planned to take college preparatory courses (Brandeis University, 1992). A decade later, Stanford University's Bridge Project found that misconceptions about effective preparation for college persisted among high school students, many of whom believed that completing the minimum program of courses required for high school graduation would equip them for postsecondary success (Venezia, Kirst, & Antonio, 2003).

Progressing to advanced courses matters for later success. A new report from the American College Testing program states: "Regardless of achievement level, students who took more than core coursework [in high school] are substantially more likely to be ready for college than students who take only the core" (2007, p. 8). This reaffirms the analyses of Adelman (1999), who used national data to demonstrate that the rigor of the high school program was a key determinant of bachelor's degree completion.

In a program for low-income students, most of whom would be first-generation college students, coaching about high school coursetaking is specifically part of the program:

> We give academic counseling. We complete their high school plan for them, and we tell them to take maximum amount of math and science possible. This just helps them when they go back to their schools.

- Inform students and their families that students need to take advanced mathematics and to begin in high school to study the scientific disciplines that interest them

For progress in science, a strong foundation in mathematics appears to be especially important. A new study by Sadler and Tai (2007) examined factors associated with success in first-year college science courses in biology, chemistry, and physics. In addition to finding that the amount of high school coursework in a particular scientific discipline was associated with better college performance in that discipline, they also found that students who had taken more mathematics in high school did better in introductory college science. On the other hand, more preparation in one science discipline conferred no benefit for performance in the other science disciplines.

Features of Tiers 2 and 3

The experiences planned for Tiers 2 and 3 have a set of common elements designed to support high school students and students transitioning to college. While INSPIRE will support and enrich students' STEM learning at the high school level, it is also important that it models the expectations and learning environments that they will encounter in higher education.

INSPIRE may also want to instill in its participants what a recent panel called "socialization to the attitudinal and behavioral demands of high academic achievement" (National Study Group for the Affirmative Development of Academic Ability, 2004). This includes habits of reading, solving problems, and asking questions; and, "accepting their ethical and moral responsibility … to work to be among the best" (p. 25). For example, the study group underscores the need to encourage students to struggle with challenging tasks rather than giving up.

Presentations

- Incorporate individual and group presentations into the project activities.

The American Diploma Project (2004) sets forth a number of benchmarks to improve college and workplace readiness among high school students. For one of these benchmarks, the report recommends using purposive group work to develop a number of skills, including listening to and building upon the ideas of others, goal setting, tolerating ambiguity and disagreement, and maintaining independence of judgment. The Urban Institute (2005) suggests that these skills may not be used enough in science teaching. Citing a study by Tobias (1993),

they note that the sciences are often "presented in too narrow a teaching and learning mode and that students with other strengths find little opportunity to use the skills they learn elsewhere, particularly verbal skills, in making sense of the material."

Incorporating presentations and group projects into INSPIRE is a project element consistent with Tobias's finding. The manager of a similar program explains that participants usually have a chance to make presentations, and that this program feature helps them see themselves as part of the scientific community:

> Presentations always help. They feel like they have something to offer. They present in their regional meetings. Or sometime coordinators and mentors put together a science fair or competition in a region, often at a university. ….Students have the opportunity to share and explain their projects. Even if there is not a big fair, student present within the organization or the company. They share with some group who asks questions. This gives them a sense of having something worthwhile to share and that they have learned something.

Joint presentations also provide an opportunity for family involvement, as culminating work can be presented to other participants and family members at the end of the summer project period. Goldberg and Sedlacek's 1995 report on the Summer Study in Engineering for High School Women noted that the program invited parents to attend their daughters' preliminary and final presentations of the summer-long team demonstration project. One of the program directors we interviewed also mentioned that this feature has been successful in her program.

Another program manager advocated the use of presentations as a way to provide students with a sense of accomplishment and a taste of professionalism.

> Presentations always help. [The participants] feel like they have something to offer. They present in their regional meeting, or sometimes [program] coordinators and mentors put together a science fair or a competition in the region [at which participants present to their peers]. . . . Students have an opportunity to share and explain their projects. Even if they don't present at a big science fair, students do present within the organization they worked with. Students might share with the Research and Development department or some group who asks the students questions. This gives them a sense of having something worthwhile to share and that they learned something.

Written Reports

- Require written reports, giving participants an opportunity to develop additional skills that are important for later academic success

According to the American Diploma Project's 2004 report, *Creating a High School Diploma That Counts*, it is essential for students to develop strong skills in writing by the time they graduate from high school. Research and writing skills, they explain, are not only vital to

success in college, but will also be required when students graduate and try to enter the workforce. The report quotes a professor of economics at San Francisco State University:

> It is a myth that mathematics and math-dependent majors in college do not require strong reading and writing skills. Students have to be able to comprehend complex informational text so they can identify which mathematical operations and concepts to apply to solve a particular problem.

Another professor is quoted in the report as noting:

> The ability to formulate and analyze arguments, both orally and in writing, is absolutely essential to academic success…we can develop these skills at the postsecondary level, but students need to get a solid foundation in these basics when they are in high school, or they will fall behind quickly in college.

The ACT National Curriculum Survey (2007) suggests that high school teachers may not be on the same page as postsecondary faculty when it comes to valuing these skills. As a result, ACT concludes, high school teachers are unintentionally falling short in adequately preparing their students in these subjects. ACT warns that failing to provide high school students with a rigorous academic curriculum can have a number of negative impacts, including making them "less likely to enroll in college, more likely to need remedial coursework during their first year of college, less likely to succeed in their college courses, and less likely to earn a college degree." As the Department of Education (2006) warns, this is not a problem of failing to take Algebra 2 in high school; "the world demands advanced quantitative literacy, and no matter what a student's postsecondary field of study…more than a ceremonial visit to college-level mathematics is called for."

A number of successful programs require that participants complete written reports on their experiences. For example, internships at NSF, offered through the Quality Education for Minorities (QEM) Network Internship Program, require both mid-term and final written reports. According to the program description, these reports are meant to "outline the individual intern's activities and document progress during the internship as well as explain specific details of the experience."

Residential Component

- Organize the summer activities on a residential basis, both to broaden access to the project and also to provide a more intense and effective experience

Incorporating a residential component is an effective way to involve students who might otherwise have difficulty commuting to a program site. As Mason and Mason (1991) note, many students in underserved areas face a lack of learning resources in their community. Including a residential aspect in an educational program helps to relieve this problem.

In focus group interviews, parents frequently mentioned the difficulty of securing transportation to and from the NASA. Aside from the inherent time difficulties involved in commuting, students often lacked resources to pay for the gasoline required for the trip.

Interviews with the managers of national STEM programs noted that a residential program allows them to recruit and enroll students who might otherwise not be able to access programs because of the location or the transportation costs of a day program:

> You're able to reach students at a national level, because only a few of our students this year were local students. So if that were important to them, you wouldn't have to worry, because you're providing housing. You wouldn't have to stay within the 50 miles.

Managers whose programs involve a residential component said that students are able to focus on the academics and become immersed in the content:

> While students are here, they are an academic captive audience…. From early morning when they wake up to late at night – they're engaged. If they have free time, it's monitored free time in a group. The class schedule is tight – they have 15 minutes to get from class to class. If they're late, they have to go to the administrative office first.

Additionally, those students who are part of INSPIRE Tier 2A and will spend time in a residential collegiate setting will not only have the academic experience, but also have the added benefit of being exposed to college and university campuses. As the managers of similar programs commented:

> In essence, these programs are of value in the sense that they provide experiential learning for students. You can talk to students in a remote location all day about the collegiate experience, but until you immerse them in it, they can't see what it's about.
>
> One main advantage when working with underrepresented populations is allowing the students, many of whom have never been on a college campus, to live and learn in that environment.

- Anticipate potential problems in order to address them.

Naturally, the prospect of running a residential program comes with its share of challenges. Although the weight of program liability might seem daunting, there are a number of steps a school or organization can take to protect their students in a legally defensible way. In an article for *The School Administrator*, Nathan Essex, a professor of educational law and educational leadership at the University of Memphis, presents several suggestions. Those relevant to the development of INSPIRE are the following:

- Model program policies after existing, well-developed policy structures.

- As explicitly as possible, list the infractions that will result in expulsion or other punishment, and make sure these are well-known to both students and parents.

The successful programs interviewed were most concerned with their structures for dealing with the residential environment, and with health issues. All three programs required students to sign several consent forms before being allowed into the program.

From a residential standpoint, several program directors noted that their residential code of conduct mirrored the existing code of their host university. In this way, they could be more secure in the thoroughness of the policies without the requirement of an independent legal infrastructure. According to one program director, it is advisable to:

> Partner with the universities in the area. It's hard to develop that from your own staff – [there are] human resources issues.

Residential programs working with college participants had more flexibility in this regard. NSF summer internships offered through Hispanic Association of Colleges and Universities (HACU) provide interns with the option of rooming with other participants through HACU-arranged housing, but interns are free to make their own arrangements or live with family in the area. While this gives interns with more freedom to choose their living environment, the sense of "campus life" is lost. Another NSF partner, Washington Internships for Native Students (WINS) requires all participants to live in the same dormitory on a local college campus.

Another area in which successful programs could boast of well-developed structure was in their staffing models. Understanding that there are usually two sets of staff, one for the academic activities and one that deals with the residential activities, one program manager observed that for the residential component, near-peer staff were able to build relationships with the students that "prevent them from violating the rules."

Some programs had a contract with a local health clinic, which allowed participants to receive services at that clinic regardless of their family's insurance status. Others required students demonstrate proof of insurance before they were allowed to attend the program.

In programs with residential components, the rules are made extremely clear to both participants and parents, on paper or in an in-person orientation. Parents and students are required to agree to the rules before students are allowed to attend the program. Program managers said that this set of group rules includes a list of unacceptable behaviors that result in immediate expulsion or other sanctions:

> We start with an orientation with parents and students on the very first day. We go through all the things we expect from them, with their parents there. We impress upon them that if they don't follow these rules, they are getting sanctioned – including going home. And so we enlist the parents to help.

In the face of these well-developed structures and explicit codes of conduct, program directors listed a few additional challenges:

> The first year I did the program, there was a student who…was 30 minutes late to curfew. We called his mom and told her to come pick him up. We agreed on the time the next morning, but then she didn't come…I ended up letting him go to the programs and activities, and she ended up coming the day after. So if you tell a parent he's out and it's the parent's responsibility to pick him up, where does that kid go that's still somewhat of a safe place?
>
> To be honest, the hardest part about having the students here was providing three meals a day. The campus dining facilities are closed during the weekends. They eat a lot, and we had to figure out where we were going to get the food.

One program director summed it up:

> Are we on pins and needles the whole time? Yeah. Because the reality is these are high school students and there's a big spectrum in the lifestyles they adhere to at home.

The same person continued:

> What we find is that once they've been there for a bit, they develop these morays and ethics as a community that helps us to monitor things.

While programs did acknowledge that there is some risk involved in running a residential program, they felt this risk was effectively minimized through residential policies that mirrored well-developed policies and a well-controlled daily schedule.

Stipends

- Provide stipends for participants, so that they do not have to forgo INSPIRE participation in order to earn money in summer jobs

By providing a stipend, INSPIRE can improve the likelihood that students from economically disadvantaged families will be able to participate. Some research indicates that such support is especially useful in gaining the participation of underrepresented minority students (Urban Institute, 2005). It has also been noted that financial assistance frees students from the schedule demands of employment, allowing them to focus on academics (Leggon & Pearson, 2006). The Urban Institute report comments: "While a job unrelated to students' academic program may detract from academic pursuits, one that is related can enrich and complement students' academic work through experiential learning."

Mentors

- Purposefully engage NASA employees and perhaps other aeronautics and space professionals in mentoring activities.

Planned, or organizational or institutionalized, mentoring is a recent outgrowth of natural mentoring, which occurs through organic means in natural circumstances. Planned mentoring "is the intentional pairing of a more experienced, older adult with a less experienced young person in order that the young person can learn from the experienced adult," according to Powell's 1997 literature review of academic tutoring and mentoring. One of the most common goals of planned mentoring programs is as a means to enhance the skills of rising professionals, as NASA seeks to do via INSPIRE.

Minority students in particular may be critically affected by a relationship with a STEM mentor. Several studies have found that minority students attribute their adjustment to college and their progress toward a graduate degree in STEM to their relationship with a mentor. One study, which focused on middle and high school students and students from a historically black university, found that students indentified personal contact with a scientist as the "major factor" influencing their decision to pursue careers in science (Freeman, 1999; Lee, 1999). The Urban Institute (2005) cites a 2001 study by Wyer that found that having positive images of scientists and engineers is positively associated with college students' commitment to a STEM major and career.

Within the context of a planned mentoring program, research has determined that both the mentors and the protégés need to have certain characteristics in order for the program to succeed. Studies suggest that adult mentors must be confident, secure, people-oriented, flexible, trusting, and sensitive to protégés' needs. The young protégés need to be open and receptive to the program (knowing about the mentoring component prior to volunteering for or applying to a any academic informal education program), and need to take responsibility for learning what the mentor has to offer.

- Build in features found to be effective in other mentoring programs

A review of the literature around organized mentoring programs uncovered the following ten critical features for success:

- Top management supports the mentoring program
- Mentoring is only one of several components integrated into a broader individualized development effort
- Participation on the parts of mentor and protégé is voluntary
- The duration of the program may be short (up to one year)
- The mentoring relationship has specific goals towards which it is focused
- There is a careful selection process set up to identify both mentors and protégés

- The roles of both mentors and protégés are defined
- Mentors and protégés are provided orientation and training
- Mentors are able to use their own style within the "structured flexibility" of the program
- Programs are monitored

These ten features suggest that a significant commitment and ownership by the mentors, the protégés, and the host organization, all of whom have important roles and responsibilities, is vital to a successful mentoring program.

Powell's literature review addressed questions of demographics and context within successful mentoring programs. Regarding demographic matching of mentors and protégés, she wrote:

> The research suggests that mentors and protégés need not be of the same race, gender or social class. For minorities and women, particularly those pursing professions and social mobility, cross-race and cross-gender mentoring may afford important contact skills and insights. However, similarity in race and gender in American society are likely to lead to common experiences and trust.

She went on to describe the way the mentoring program should fit into the lives of its participants:

> Mentoring needs to be contextual, taking into account other relationships, institutions and real and perceived opportunities. Planned mentoring often leans on, and works in tandem with other interventions, and they affect its success. The degree to which mentoring is integrated with other interventions affects its potential success.

Program managers agreed in interviews that it is not only important that mentors have a STEM background, but that they are also consistent and supportive role models for students, as well.

> We see our mentors as "coaches, catalysts, and consultants" for the kids. I have found the very best mentors don't necessarily have the best technological background but are willing and able to help the kids work through the processes. The kids can see that adults don't always have the answer… and that sometimes there isn't one right answer. Good mentors model how to think through problems. I think we're looking for people [to be mentors] who have the right sensibilities about working with kids and learning, rather than technical people. People with a shared mindset about what it means for kids learning to design and think creatively.
>
> As far as the way our mentoring is structured, we ask our mentors to provide regularity, consistency. For our Clubhouse, we have mentors sign up for a whole half a year. For most of the projects the kids do we have them working together in groups. Mentors aren't necessarily assigned to any one group of kids – they tend to go from group to

group, answering questions, asking questions, and guiding the groups through the processes.

Good mentors help the students enjoy and fall in love with what they are doing. They help them love science. . . . Good mentors give [the participants] a network of colleagues, so they can meet many scientists and develop communications skills with those in the field. That way they can present their ideas to many people within the field.

Evaluation

Our evaluation recommendations include adhering closely to NASA's evaluation framework for K-12 projects, especially the PART measures. However, NASA should not jump directly to measures of outcomes but instead should use a design appropriate to the stage of project development. This means beginning with descriptive data and formative feedback on outputs and outcomes, while establishing the groundwork and expectations for longitudinal tracking of participants. Eventually, NASA will want to establish a counterfactual for outcome measures.

Output Measures That Document What Has Happened

There are several reasons to measure initial outputs, as listed below. Documenting the initial implementation activities will provide a pool of ideas for continuing project refinement. Also, descriptive data on participants will inform ongoing reporting and can eventually be used in measuring project effectiveness. The following outputs should be measured:

- Offerings – maintain records of all INSPIRE activities and events held, including mentoring, and "opportunities for family involvement" (PART measure)
- Attendance – count students, parents, lower grade level mentees, mentors/ other NASA personnel participating in all INSPIRE activities and events, including "number of K-12 participants" (PART measure)
- Demographics – break out INSPIRE participants by gender, race, ethnicity, age/ grade
- Materials – document and archive materials produced and used by INSPIRE
- Technology – document development and use of technologies that facilitate distance learning
- Partnerships – document work done to create or enhance partnerships with organizations outside NASA

Outcome Measures That Gauge Changes among Youth and Families

In the early stages, demonstrating the existence of changes will establish a tentative basis for claiming that the project is on the right track toward success. Areas in which changes are slight or nonexistent will point to needed project improvements, as will the participant surveys. The following types of measures are recommended, corresponding to NASA's K-12 outcome measures:

- Pre and post tests measuring gains in student content knowledge in science and technology ("level of student learning about science and technology")
- Pre and post tests measuring student awareness of and interest in fields of study related to STEM ("increased student interest in STEM")
- Pre and post tests measuring student knowledge of and interest in careers related to STEM ("increased student knowledge about careers in STEM"; "increased student interest in science and technology careers")
- Pre and post tests measuring student awareness of educational paths/ courses that are important to the attainment of a degree or career in STEM fields
- Pre and post tests measuring family participants' information about and interest in students' STEM coursework ("increased interest in students' STEM coursework")
- Surveys of participants, parents, staff, middle-school protégés, mentors – what worked well, what didn't work as well, suggestions for improvement

Groundwork for Longitudinal Study

Tracking participants' subsequent progress through the pipeline to academic and career outcomes will be important. In other projects and programs, managers who lack systematic evidence of longer-term outcomes regret this lack. Establishing a clear expectation of follow-up communication will greatly ease the challenges of longitudinal tracking. Thus, INSPIRE should establishing a system for staying in contact with alumni and should maintain a database of current contact information including name, parents' address, current address, email address, schools attended, etc.

Future Comparative Study

Once the implementation of the project has stabilized and pre/post changes have been demonstrated, it will be appropriate and necessary to generate a suitable counterfactual for the observed results (i.e., a measure of what would have happened in the absence of the project). A randomized controlled trial, although very expensive and burdensome, is considered the gold standard. Other designs are also somewhat expensive and burdensome, and will be subject to

considerably more criticism. The following steps would be involved in setting up a randomized controlled trial:

- As the project matures, consider use of random selection from a pool of finalists for participation
- Administer all pre, post, and longitudinal measures to both treatment and control students
- Provide control students with an incentive for participation (e.g., attendance an annual event; packets of NASA materials on science, technology, and career planning)

References

Adelman, C. (1999). *Answers in the tool box: Academic intensity, attendance patterns, and bachelor's degree attainment*. Washington, DC: U.S. Department of Education.

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college*. Washington, D.C.: U.S. Department of Education.

American College Testing (ACT). (2007). *Rigor at risk: Reaffirming quality in the high school core curriculum*. Iowa City, IA: Author.

American College Testing (ACT). (2007). *ACT National Curriculum Survey: 2005-2006*. Iowa City, IA: Author.

Asplund, Shari. (2005). "How can NASA work with, listen to, and learn from existing afterschool networks?" *NASA and Afterschool Programs: Connecting to the Future*. American Museum of Natural History. Appendix D:129-134.

Bardick, A.D., & Bernes, K.B. (2005*). Occupational aspirations of students in grades seven to twelve*. Ottawa, Ontario, Canada: The National Consultation on Career Development (NATCON).

Baker, D.P., & Stevenson, D.L. (1986, July). Mothers' strategies for children's school achievement: Managing the transition to high school. *Sociology of Education*, *(59)3*, 156-166.

Borland, J.H. (2004, May). *Issues and practices in the identification and education of gifted students from under-represented groups* (RM04186). Storrs, CT: The National Research Center on the Gifted and Talented.

Brandeis University, Center for Human Resources. (1992, Fall). Future options education: Careers and middle school youth. *Youth Programs*, 1-29.

Bransford, J., Brown, A., & Cocking, R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Breakthrough Collaborative: Success Stories. "A Breakthrough Report from Stanford University." Available online at http://breakthroughcollaborative.org/successstories/index.html

Brown, A.L., & Campione, J.C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-70). Cambridge, MA: MIT Press.

Boylan, M. (2006). *The Impact of Undergraduate Research Experiences on Student Intellectual Growth, Affective Development, and Interest in Doing Graduate Work in STEM: A review of the empirical literature.* Cornell Higher Education Research Institute. National Science Foundation.

Bureau of Labor Statistics. (2007). College enrollment and work activity of 2006 high school graduates. Available online at http://www.bls.gov/news.release/hsgec.nr0.htm.

California Association of Peer Programs. (2005). *About peer programs*. Pasadena, CA: Author. Available online at http://cappeer.org/all_about_peer_programs.htm.

Campbell, P.B., Jolly, E., Hoey, L., & Perlman, L.K. (2004, January). *Upping the numbers: Using research-based decision making to increase diversity in the quantitative disciplines* (A report commissioned by the GE Foundation). Newton, MA: Education Development Center, Inc.

Carr, R.A. (1996) "Positive peer pressure: A transition perspective." *Family Connections*. B.C. Council for the Family. Available online at http://www.cfc.efc.ca/docs/fscan/00000410.htm

Catsambis, S. (1994). The path to math: Gender and racial-ethnic differences in mathematics participation from middle school to high school. *Sociology of Education, 67*, 199–215.

Clark, R. (2002, December). Building student achievement: In-school and out-of-school factors. *NCREL Policy Issues*, *(13)*. Available online at http://www.ncrel.org/policy/pubs/html/pivol13/dec2002c.htm.

Committee on Science, Engineering, and Public Policy. (2005). *Rising above the gathering storm: Energizing and employing America for a brighter economic future* (Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology). Washington, DC: The National Academies Press.

Duschl, R.A., Schweingruber, H.A., & Shouse, A.W. (Eds.). (2007). *Taking science to school: Learning and teaching science in grades K-8* (A National Research Council report). Washington, DC: The National Academies Press.

Essex, N.L. (1999). Safeguarding rights, minimizing exposure. *The School Administrator*. American Association of School Administrators. Available online at: http://www.aasa.org/publications/saarticledetail.cfm?ItemNumber=3482.

Federation of American Scientists. (2003). The learning federation LS&T R&D roadmaps: Building simulations & exploration environments R&D for technology-enabled learning systems." Available online at http://www.learningfederation.org/sse.pdf

Ferreira, M. (2001). The effect of an after-school program addressing the gender and minority achievement gaps in science, mathematics, and engineering (*ERS spectrum).* Arlington, VA: Educational Research Service.

Finn, P. (1981). Institutionalizing peer education in the health education classroom. *Education Leadership*, *51*, 27-30.

Ford, D.Y., & Harris III, J.J. (1999). *Multicultural gifted education.* New York: Teachers College Press.

Freeman, K. (1999). No services needed? The case for mentoring high-achieving African-American students. *Peabody Journal of Education*, 74 (2), 15-26.

Gándara, P. (2005). *Latino achievement: Identifying models that foster success* (RM04194). Storrs, CT: The National Research Center on the Gifted and Talented, University of Connecticut.

Gloria, A.M. & Hird, J.S. (1999). Influences of ethnic and nonethnic variables on the career decision-making self-efficacy of college students. *Career Development Quarterly*, *48* (2), 157-74.

Goldberg, J.L., & Sedlacek, W.E. (1995). *Summer study in engineering for high school women*. College Park, MD: University of Maryland, Counseling Center, Office of Vice President for Student Affairs.

Good, J., Halpin, G., & Halpin G. (1998). *The affective and academic benefits for mentors in a minority engineering program.* (ERIC Document Reproduction Service No. ED 439488).

Hansen, W.B. (1988). Drug abuse prevention: Effective school-based approaches. *Educational Leadership*, *45*, 9-14.

Hrabowski, F.H., Maton, K.I., Greene, M.L., & Greif, G. (2002). *Overcoming the odds: Raising academically successful African American females*. New York: Oxford University Press.

(http://docs.moodle.org/en/Philosophy)

Johnson, D. Johnson, R. (1987). Research shows the benefits of adult cooperation. *Educational Leadership*. *45*, 27-30.

Karcher, M.J., Davis, C. & Powell, B. (2002). Effects of developmental mentoring on connectedness and academic achievement. *School Community Journal*, *12(2)*. Lincoln, IL: Academic Development Institute.

Kerka, S. (1994). *Vocational education in the middle school* (ERIC Digest No. 155). Columbus, OH: ERIC Clearinghouse on Adult Career and Vocational Education.

Koszalka, T.A. (2002). Technology resources as a mediating factor in career interest development. *Educational Technology and Society*, *2* (5), 29-38.

Laughlin, D. (2007). *NASA eEducation research and development implementation guide.* Prepared for NASA eEducation. (Revised: March 2007). .NASA Learning Technologies.

Laughlin, D., Roper, M., & Howell, K. (2007, August 6). *NASA eEducation roadmap: research challenges in the design of persistent immersive synthetic environments for education and training*. Prepared for NASA eEducation.

Laughlin, D. (2007, August 6). *Persistent immersive synthetic environments*. Paper presented at the STS-118 Pre-Launch Education Conference, Innovative Strategies for Cultivating the STEM Workforce, Orlando, FL.

Lee, W. Y. (1999). Striving toward effective retention: The effect of race on mentoring African American Students. *Peabody Journal of Education*, 74 (2), 27-43.

Leggon, Cheryl B. and Pearson, Willie Jr. (2006). *Assessing Programs to Improve Minority Participation in STEM Fields: What We Know and What We Need to Know*. ADVANCE Program Conference, January 2007. University of Michigan.

Lundberg, C.A. (2003). Nontraditional college students and the role of collaborative learning as a tool for science mastery. *School Science and Mathematics, 103* (1) 8-17.

Mason, M.M., & Mason, W.B. (1991). Project S.C.A.M.P. (science, computer, and mathematics professions): A young scholars program for academically talented rural youth. *Reaching Our Potential: Rural Education in the 90's* conference proceedings, Rural Education Symposium, (March 17-20), Nashville, TN.

McDonald, J. Grove, J., & Forum, Y.A. (2000). *Youth for youth: A project to develop skills and resources for peer education: Final report*. Adelaide: National Centre for Education and Training on Addiction, Flinders University of South Australia.

McDonald, J.L., & Jessell, J.C. (1992, Summer). Influence of selected variables on occupational attitudes and perceived occupational abilities of young adolescents. *Journal of Career Development*, *18(4)*, 239-249.

McHugh, M.W. (2006). Governor's schools: Fostering the social and emotional well-being of gifted and talented students. *The Journal of Secondary Gifted Education, XVII(* 3), 178-186.

Mills, Dishon. (2005). "Reaching Out: A Call for Community Engagement." *NASA and Afterschool Programs: Connecting to the Future*. American Museum of Natural History. Appendix D: 126-128.

National Center for Education Statistics. (2007). *The condition of education 2007* (NCES 2007-064). Washington, DC: U.S. Department of Education.

National Research Council Committee. (2007). *Building a better NASA workforce: Meeting the workforce needs for the national vision for space exploration*. Washington, DC: The National Academies Press.

National Science Board. (2006). *Science and engineering indicators 2006.* (Two volumes: (Volume 1, NSB 06-01; Volume 2, NSB 06-01A). Arlington, VA: National Science Foundation.

National Science Board. (2004). *Broadening Participation in Science and Engineering Faculty.* Arlington, VA: National Science Foundation.

National Science Foundation, Division of Science Resources Statistics. (2007, February). *Women, minorities, and persons with disabilities in science and engineering: 2007* (NSF 07-315). Arlington, VA: Author.

National Science Foundation. (2001). *Survey of public attitudes toward and understanding of science and technology 2002*. Arlington, VA: National Science Foundation.

National Study Group for the Affirmative Development of Academic Ability. (2004). *All students reaching the top: Strategies for closing academic achievement gaps*. Naperville, IL: Learning Point Associates, & North Central Regional Education Library.

Organisation for Economic Cooperation and Development. (2006, May 4). *Evolution of student interest in science and technology studies* (Policy report). Paris, France: Author.

Phillips, K.A., Barrow, L.H., & Chandrasekhar M. (2002). *Science career interests among high school females one year after participation in a summer science program*. Arlington, VA: National Science Foundation.

Powell, M.A. (1997). *Academic tutoring and mentoring: A literature review*. California Research Bureau, California State Library (CRB-97-011).

Public Agenda. (2006). *Are parents and students ready for more math and science?* (Education Insights: Issue No. 1). *Reality Check 2006, (1)*, 1-19. New York: Author. Available online at http://www.publicagenda.org/research/pdfs/rc0601.pdf.

Resnick, M., et al. (2000). *The PIE Network: Promoting science inquiry and engineering through playful invention and exploration with new digital technologies*. Proposal to the

National Science Foundation (project funded 2001-2004). Available online at http://web.media.mit.edu/~mres/papers/pie/

Resnick, M., Rusk, N., & Cooke, S. (1998). The Computer clubhouse: Technological fluency in the inner city. In D. Schon, B. Sanyal, & W. Mitchell. (Eds.), *High technology and low-income communities*, pp. 266-286. Cambridge: MIT Press. Available online at http://web.media.mit.edu/~mres/papers/clubhouse-chapter.pdf

Roschelle, J., Pea, R., Hoadley, C., Gordin, D., & Means, B. (2001). Changing how and what children learn in school with computer-based technologies. *The Future of Children*, *10*(2). Los Altos, CA: Packard Foundation. 76-101.

Russell, J. (1999). Insuring work-based learning experiences. *The School Administrator,* American Association of School Administrators. Available online at: http://www.aasa.org/publications/saarticledetail.cfm?ItemNumber=3723.

Sadler, P.M., & Tai, R.H. (2007, July 27). Transitions: The two high-school pillars supporting college science. *Science*, *(317)*5837, 457-458.

Schiel, J. (1998). *Academic benefits in high school of an intensive summer program for academically talented seventh graders*. *ACT Research Report Series*, 98-4.

Shettle, C., Roey, S., Mordica, J., Perkins, R., Nord, C., Teodorovic, J., Brown, J., Lyons, M., Averett, C., & Kastberg, D. (2007). *The Nation's report card: America's high school graduates* (NCES 2007-467). Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Snyder, T.D., Dillow, S.A., & Hoffman, C.M. (2007). *Digest of education statistics 2006* (NCES 2007-017). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Solorzano, D.G. (1993). The road to the doctorate for California's Chicanas and Chicanos: A study of Ford Foundation Minority Fellows. CPS report. (ERIC Document Reproduction Service No. ED374941).

Springer, L., Stanne, M.E., & Donovan, S.S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research*, *69*(1), pp. 21-51.

Stanton-Salazar, R. (1997). A social capital framework for understanding the socialization of racial minority children and youths. *Harvard Educational Review, 67*(1), 1-40.

Tai, R.H., Liu, C.Q., Maltese, A.V., & Fan X. (2006, May 26). Planning early for careers in science. *Science*, *312*, 1143-1144.

The National Study Group for the Affirmative Development of Academic Ability. (2004). *All students reaching the top: Strategies for closing academic achievement gaps*. Naperville, IL: Learning Point Associates and North Central Regional Education Library.

National Institute on Out-of-School Time, Wellesley, MA - A Review of the Literature and the INSPIRE Model STEM in Out-of-School Time June 2007

The American Diploma Project. (2004). *Ready or not: Creating a high school diploma that counts*. Achieve, Inc.

Treisman, U. (1992). Studying students studying calculus: A look at the lives of minority mathematicians (A Mary P. Dolciani Lecture). *College Mathematics Journal, 23*, 362-372.

U.S. Department of Education. (2007, May). *Report of the Academic Competitiveness Council*. Washington, DC: Author.

The Urban Institute. (2005). *Final Report on the Evaluation of the National Science Foundation Louis Stokes Alliances for Minority Participation Program*. Arlington, VA: National Science Foundation.

Venezia, A., Kirst, M.W., & Antonio, A.L. (2003, March). *Betraying the college dream: How disconnected K-12 and postsecondary education systems undermine student aspirations*. Stanford, CA: The Bridge Project, The Stanford Institute for Higher Education Research.

Walker, G., Wahl, E., & Rivas, L. (2005). *NASA and Afterschool Programs: Connecting to the Future*. American Museum of Natural History.

Appendix: Methods

PSA's review of current literature began with the macro issues in U.S. education and issues specifically related to STEM education. A number of up-to-date reports on available education data were analyzed in order to gauge the basic attainment levels of today's high school students across disciplines and demographics. This snapshot of education in America was also examined comparatively across time to spot trends. Moving from this macro view, PSA turned its attention to the framework of concerns about STEM education outlined in *Rising above the Gathering Storm*. PSA supplemented this milestone report by examining current statistical reports on the state of STEM education. These reports helped place STEM education into both an academic context relative to other disciplines of study, and a demographic context that indentified underserved populations. Similar statistical reports on the pursuit of STEM careers were also utilized in an effort to address NASA's workforce needs and identify the STEM workforce trends of the 21st century.

From there, the PSA review moved on to a body of literature on how best to foster enthusiasm for the STEM fields, encourage diversity, and inspire learning among students. PSA examined both prescriptive reports and the underlying studies used to develop these prescriptions. This review focused mainly on recommendations aimed at middle school and high school students, although literature aimed at all age groups was incorporated. Additionally, as PSA investigated each potential element in INSPIRE, it was important to understand the reasoning and research evidence behind potential project components such as parent involvement, mentoring, and the use of technology in distance learning. Delving into these bodies of literature helped inform NASA's decisions for the INSPIRE design.

PSA then identified promising practices from a wide range of programmatic sources. Beginning with lists of programs provided by NASA, PSA located out-of-school programs around the country that shared INSPIRE's basic aims and that targeted the middle-school or high-school grades. Using the web pages of professional societies, universities, federal agencies, and corporate sponsors, PSA rigorously examined potential programs for benchmarking. In searching for programs that succeed in engaging students in STEM and equipping students to progress through the educational transitions in order to attain a degree, PSA focused the search on programs with some documented evidence of their effectiveness.

Having narrowed the focus to programs that were comparable to INSPIRE in their aims and that had some evidence of effectiveness, PSA documented the programs' use of several features contemplated for INSPIRE: whether program goals include explicit encouragement of STEM careers and/or STEM college majors; whether the program includes a mentoring component, a family component, a distance learning/technology; whether or not the program specifically recruits students from underrepresented groups; whether the program pursues the "best and brightest" of the targeted student group (either through competition or admission requirements); and whether the program involves partnering organizations, especially government agencies or non-profit organizations.

From the original list of programs, PSA researchers contacted 14 to learn from the director what practices he or she considered most effective and promising. These telephone interviews addressed, for example, the lessons they had learned over time in implementing specific program elements such as family involvement, mentors, internships, and distance learning, and what advice they might have for NASA in designing and implementing INSPIRE.

A third information source for this study was a set of focus groups. PSA worked with NASA and its consultant, Tim Kotnour, to develop questions for groups of students, parents, and educators. Dr. Kotnour then traveled to the NASA centers to conduct the groups. Across the sites, he conducted four focus groups of students in grades seven through ten, for a total of 28 younger students, seven focus groups of students in grades 11, 12, and early college, for a total of 39 older students, three focus groups of parents, for a total of 15 parents, and five focus groups of educators, for a total of 21 educators. He summarized their responses, across and within groups, in a report to NASA, and this PSA report cites the relevant responses.