NASA Explorer Schools

2004 Cohort

Case Study Reports and Summary Rubric Scores

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NASA Explorer Schools Case Study Profile: A126
2004 Cohort—Mid-size City, Georgia Public Elementary School: PreK-5

Summary Comments Regarding A126
A126 is a PK-5 school in the foothills of the Blue Ridge Mountains in Georgia. The student population has grown more diverse since its 2004 acceptance into the NES project. The number of Hispanic students increased from 281 to 403 from 2004 to 2005, and this reflected a 6 percent increase in students classified as English language learners. A126's total enrollment was 497 students during 2003-2004; that increased to 608 in the 2004-2005 school year. In 2005, A126 met the qualifications for Title I support. Between 2004 and 2005, the number of teachers increased from 10 to 22. See Table 1 for more demographic information.

Here are some of the successes that A126 achieved during its three-year period as a NASA Explorer School:

- The after-school science club successfully attracted students to participate in open-ended inquiry science learning. The club activities use a variety of technologies.
- The A126 administrator said NES has helped the school increase student and parent attendance at school activities.
- The A126 administrator has observed changes in students' attitudes toward science and math. Students are talking about things related to science and math that they learned in class between classes and outside of school.

As a school that serves a predominantly poor population and high percentage of English learners, A126 must overcome challenges that compete with STEM-G-related reform activities for teacher and administrator attention. Here are some of these challenges:

- Lack of time to incorporate NASA activities into classroom teaching. Because of the high-stakes standard tests, teachers have to find ways to make things work within state requirements before doing anything else.
- The late arrival of the NES funding has caused delays in the implementation process. The team reported that it could not start the robotics activities and had to borrow money to buy the equipment.
- Teachers said they used to have some conflict in personality issues among team members. Ongoing conversations and adjustments have helped to resolve the problem.

We examined schoolwide achievements at A126 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcripts of

one focus group interview conducted by telephone with the A126 NES team. The interview was conducted May 10, 2006. We have also used the school website, survey data, the NASA Explorer Schools e-Folio, and U.S. Department of Education school data to expand upon information provided in the interviews.

Outcome 1: Increased participation and professional growth of educators in science.

The NES A126 team consists of five members, including an administrator, who serves as principal of the school. The team lead teaches kindergarten to fifth grade. One of the team members teaches fourth grade math, and another teaches fifth grade reading. At the beginning of the year, the team met about two or three times a month. Toward the end of the year, members did not meet as often, but rather as much as they felt was necessary.

In 2006 the team said it intended to use its third year of NASA monetary support to:

- Purchase equipment to increase technical capabilities and continue the existing Explorers Club.
- Include more students and provide extension activities for those who participated last year, i.e., expanding the club to include local elementary schools through a Saturday club and a summer club.
- Refine Science Fun Night opportunities for parents and students.

In addition, the school also planned the addition of a shade pavilion for outdoor classroom activities so that the space may be used more months of the year. Tables 3 and 4 provide a summary of the professional development opportunities and NASA resources that A126 has taken advantage of as a NASA Explorer School.

The next section examined the extent to which the A126 school implementation of NES addresses the six guidelines for professional growth and development described below.

Guideline 1: Instructional Strategies.
Teachers and the administrator serving on the A126 NES team responded enthusiastically to the opportunities to incorporate more hands-on and inquiry activities into their curriculum. Evidence of teachers applying what they learned about inquiry methods and creating learning environments for their students is contained in the NES digital portfolio that includes teacher reports on their classroom implementation of these activities. Here are team comments about NES professional development to support these instructional changes.

- The administrator said the NES project "is a wonderful way to get science and math incorporated into the regular curriculum, make sure students know the importance of science, and get students interested in science and math" (Focus Group Interview, May 10, 2006).
- The team lead said the NES project "is a way to get students excited about science, because they have a natural curiosity about space and astronauts, and this is to get them interested in learning about science." A math teacher said, "I was expecting to have a lot of support and new ideas brought into the school and just in different ways to teach science and bring it into our curriculum" (Focus Group Interview, May 10, 2006).
- The team lead said, "They have developed an after-school science club. They have incorporated robotics in that club and developed a Mars project for the fifth grade classes" (Focus Group Interview, May 10, 2006).

In addition to our analyses from the case study, we report some key findings from the survey data on A126. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings:

- When asked how often students in this class take part in hands-on/ laboratory activities, two teachers responded "1-3 times per month," one responded "1-3 times per week," and one responded "almost every day" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often students in this class work in small groups to come up with joint solutions or approaches to a problem or task, three out of four teachers responded "1-3 times per month," and one responded "1-3 times per week" in the TLC survey.
- Here is how teachers responded to questions in the TLC survey regarding how often they accomplish the following goals:
    - Elicit students' ideas and opinions: Two teachers responded "often," one responded "very often," and one responded "always."
    - Get students to justify and explain their reasoning: Two out of four teachers responded "very often," one responded "often," and another responded "always."
    - Have students relate what they are working on to their own experience: Two out of four teachers responded "very often," one responded "often," and another responded "always."
- Twenty-one teachers completed the Teacher Need and Involvement survey. In responding to how much they anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, only two teachers responded "quite a lot" and "a lot," while the rest of teachers responded "some," "a little," or "not at all." This implies that the integration of NES schoolwide is still in progress.

Guideline 2: Time Intensive.
A126 team and non-NES teachers have been actively involved in the science fun nights. The NES team has teachers from each grade working to develop centers and activities for the science fun nights. They also have done staff development for other faculty members and given them ideas that are related to the NES program.

Guideline 3: Classroom Practices.
The A126 team lead said the program has given her a "huge bag of tricks" (May 10, 2006). She now has more hands-on activities to do with students. Instead of using made-up data, she has real data to work with the kids, and this makes the science real for them. "They are not just learning something that they will never use" (Focus Group Interview, May 10, 2006).

The NES digital portfolio provides teacher reflections regarding how integration of newly learned teaching strategies and inquiry-based activities. Here is A126 teacher reflections on GLOBE activities conducted in January of 2007. This excerpt shows how the A126 teachers are building content connections between activities and carefully observing the student performance during each activity.

- "After completing a weather unit, 4th grade students will rotate the collection of GLOBE atmospheric data. This includes cloud observation, temperature and humidity. They also enter the data on the GLOBE website weekly…This activity did not go as well as in previous years. I had difficulty getting students who would be consistent in their data gathering."[1]

Guideline 4: Content Knowledge.
A126 teachers viewed their participation in NES-related opportunities as a way to address their content knowledge in science and math. As one teacher explained:

- "Personally this year, it helped to increase my interest in science and use it in math. I teach math, but my science has been increased, and I got to go to the National Council of Teachers of Mathematics conference in St. Louis. I learned more in that weekend probably than I ever did in college. It was just amazing. So personally those things have been very beneficial to me" (Focus Group Interview, May 10, 2006).

Guideline 5: Active Learning.
The team has played different roles in terms of the implementation process and has found a way to implement NES activities in interdisciplinary activities. For example:

[1] Copied July 18, 2007 from http://aesp.nasa.okstate.edu/efolio/

- A126 has a liaison for grades 4-5. A126 school has a science literacy teacher who has been able to use science as a vehicle to teach language arts and reading.

The workshops have made it easy for teachers to understand how they need to implement things, and the workshops have given them new ideas to implement. AES and field center staff have been to the school and offered assistance.

- The AES "assisted us in getting the Mars project started. He does things for family fun night. He brought rockets to the school and taught students and parents" (Focus Group Interview, May 10, 2006).

Guideline 6: Coherence.
It has been difficult for teachers to incorporate as many of the NASA activities that they would like because the classroom time is tightly structured by No Child Left Behind requirements. As the teachers and team administrator explained:

- "We have so many things that we are required by the state to teach, although we would like to be able to do a lot more things. With No Child Left Behind we have to get our adequate yearly progress" (Focus Group Interview, May 10, 2006). But "because our children have been doing science activities, they are better prepared when they go to middle school."
- The administrator said "we have people that come in and out visiting our school, touring the school. We highly recommend them to become one of the NES schools" (Focus Group Interview, May 10, 2006). Another NES teacher said that "[NES] has been great PR for the school. It's been wonderful to be called a NASA Explorer School. We see excitement in our kids' faces when they say we are a NASA Explorer School" (Focus Group Interview, May 10, 2006).

Summary of How A126 Meets Outcome 1.
With the high number of English learners, A126 teachers have tried to integrate science literacy with English literacy, but many NES activities have had to take a secondary role. The NES A126 team developed an after-school robotics club for students to participate in some of the NASA activities. Teachers have more hands-on activities that include using real science data and making the science real for their students. Overall, the A126 team was positive about the NES project, and the project has helped teachers to gain more their science knowledge and improve their teaching strategies.

Outcome 2: Increased assistance for and technology use by educators in schools with high populations of underserved students.

A126 purchased the following technologies with NES funding:

- Videoconferencing equipment
- Computers
- LEGO robotics
- GLOBE program

With the assistance of AES, A126 team tested its distance communications equipment and hooked up with Damon Talley at Kennedy Space Center (KSC).

We incorporated some of the data from the Teaching, Learning, Computing (TLC) and Teacher Need and Involvement surveys to generate a more inclusive picture of how A126 teachers integrate technology. When teachers were asked how many days a year a typical student in the class uses a computer while they are teaching their class, teachers responded only "1-5 times" a year. Teachers also responded only "1-5 times" for using NASA materials in their classroom in a year.

Outcome 3: Increased family involvement in children's learning.

Searching for postings about A126 outreach and family events on the web, we found the following comments from parents of A126 students. A126 parents are concerned about the administrative rules and school safety issues.

> "Not a school from the good old days, when they still included fun into the curriculum as a way of learning. Way too strict on the kids" (April 2006).
>
> "After getting recognition by the president for CRCT scores, their heads swelled up! That principal moved to Arizona right after, and the one that took his place, takes all the credit. Don't ask her to help solve a problem that involves your child, whether it is due to a bully, or it's one of her teachers who likes to yell at your child, etc. She simply doesn't have the time....Correct me if I'm wrong, but isn't it about the child? Not at this school"(February 2006).

Outcome 4: Increased student interest and participation in STEM-G.

A126 teachers have observed their students' interests and participation in NASA activities increase, and some students who graduated to high school would come back and ask for more resources. Students seem to ask more questions in regard to the science matters, which seldom happened before. Students' participation in

the regional field center and hands-on activities have made students' science attitude change.

The following strands are indicators of what it means for students to have interest and to participate in STEM-G activities. Students who are interested and participate in STEM-G activities have the tendency to:

Participate productively in STEM-G practices and discourse.
The A126 school administrator said, "Students who were fifth-graders last year and are in middle school now would come back to the science fun nights with their siblings. It is good to see those kids come back. It gives them a chance to still be a part of [A126] exploration academy" (Focus Group Interview, May 10, 2006).

Changes in self-concept.
"A lot of kids are from poverty backgrounds. They do not have much, and a lot of them are second language learners. When they were in Kennedy, they were treated so well. They were so excited about being treated so nicely" (Focus Group Interview, May 10, 2006).

Attitudes changes about learning.
The A126 school administrator has observed the change in students' attitudes. "Just the things kids are learning in science and math. You can hear them talking about it in the hallways. You know they are talking about something that was exciting in the class that day that related to science or math. It is just great to see. Now when you ask them what did you learn in school today, they have something to say" (Focus Group Interview, May 10, 2006).

Actively participate in hands-on and authentic scientific research.
The Explorers Club is designed to give students science and technology experiences outside the regular school day. Students used the LEGO robotics "Mission to Mars Challenge" to design and program a robot to travel on the Mars surface. They also designed a rocket to make an unmanned mission.

Outcome 5: Increased student knowledge about careers in STEM-G.

Students are more engaged in scientific inquiry and asking scientists questions during the field trip to the field center.

The following strands indicate students' knowledge about careers in STEM-G. Students who demonstrate knowledge about careers in STEM-G also demonstrate:

Increased understanding of and enthusiasm about STEM-G careers.
"In Kennedy students got to go to the front of the line and meet people whom the regular public did not get to meet. One of the little girls said she was so impressed talking to the astronaut, that the astronaut was telling her how it looked from space, and she said she could not wait. She wanted to go up into space so that she could see it herself because she could hardly believe what he told her" (Focus Group Interview, May 10, 2006).

Outcome 6: Increased student ability to apply STEM-G concepts and skills in meaningful ways.

Many science-related activities are lined up for students to take part in. Students are constantly making presentations to their peers and family to showcase what they have accomplished in the school. This gives students a sense of confidence that they can do things that they never could have if not for NES. During the partnership with NES, students' achievement scores in English and math have outperformed many other non-NES schools.

Understand and use scientific explanations of the natural world in context of a problem-solving activity.
[As projected by the A126 team in the NASA e-Folio] In the Star Lab, Elachee Nature Center will bring its inflatable planetarium to school. The naturalist will present concepts connecting to the Georgia Performance Standards. These relate to the characteristics of the planets and the stars. The program outside the planetarium prepares the students for the star program inside. Students not only get to see how the planets move across the sky but also see how the stars make pattern or constellations.

Understand how to use and interpret the data obtained from technology tools to support STEM-related inquiry activities.
[As projected by the A126 team in the NASA e-Folio] In the Science Fair: This was an activity that involves the arts and technology with science. The Drama Club will present a play, Tales on the Mars Frontier. The music department had appropriate songs. Third grade students presented their Georgia project using Kids Pix software. Fourth grade students presented lunar projects using PowerPoint. Fifth grade students and Explorer Club students presented their models of a Mars colony.

Evidence is available to demonstrate student performance increased in STEM and related subjects like language arts.
In searching for any web posting about A126, we found a newspaper story that discussed improvements in student achievement at A126. Improvements at A126

even received national attention, as this article indicates, "Last September, President Bush recognized the school in his acceptance speech at the GOP convention for having high test scores despite having a high number of students who are either poor or speak limited English, or both."[2]

A high-level summary of the A126 math and language arts achievement scores reported for 2003-2004, 2004-2005, and 2005-2006 shows that while there were gains from the 2003 school year to the 2004 year, the 2005-2006 academic year did not sustain the improvements of previous year. The percentage of non-English speaking students increased between the 2003 and 2004 school years by 6 percent, and the number of Hispanic students increased by 18 percent. We would expect the changes in school population to have some impact on the school's instructional needs and student achievement.

[2] Source retrieved July 17, 2007, from http://www.gainesvilletimes.com/news/stories/20050905/localnews/12711.shtml

Table 1. School Demographics

	2003-2004	2004-2005	2005-2006
Student Population	497	608	
Black, non-Hispanic	100	101	
Asian	30	36	
Hispanic	281	403	
American Indian, Alaskan Native	0	1	
White, non-Hispanic	86	47	
School Location (rural, suburban, urban, large central city)	Mid-size City	Mid-size City	
School Type (public, private, charter, magnet)	Public	Public	
Title 1 status (yes or no)	No	Yes	
English Language Learners	56%	62%	
Free and Reduced Price Lunch	80%	88%	
Teacher Population	10	22.5	

Note: Grayed-out cells indicate that data is not available as of March 14, 2007.

Source: Georgia Department of Education. (2005-2007). Retrieved March 13, 2007, from http://www.doe.k12.ga.us/

Table 2. Summary of Academic Needs Identified by A126 in 2004

Priority	Discipline	Category	National Standard
1	Principles and Standards for School Mathematics	Problem Solving	Apply and adapt a variety of appropriate strategies to solve problems
2	Principles and Standards for School Mathematics	Connections	Recognize and apply mathematics in contexts outside of mathematics
3	Standards for Technological Literacy	The Nature of Technology	Students will develop an understanding of the core concepts of technology
4	Principles and Standards for School Mathematics	Measurement	Apply appropriate techniques, tools, and formulas to determine measurements
5	Principles and Standards for School Mathematics	Data Analysis and Probability	Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
6	National Geography Standards	The World in Spatial Terms	How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.
7	Principles and Standards for School Mathematics	Communication	Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
8	National Geography Standards	Environment and society	How human actions modify the physical environment.
9	Standards for Technological Literacy	Technology and Society	Students will develop an understanding of the effects of technology on the environment
10	National Educational Technology Standards		Use content-specific tools, software, and simulations to support learning and research.

Source: A126 Needs Assessment. (2004).

Table 3. NASA Professional Development Opportunities That A126 Teachers Completed

NES summer orientation workshop*
NES summer content workshop*
AES teacher workshops*
NASA student symposium*
National Council of Teachers of Mathematics Conference, St. Louis*
Staff development on site at A126*
NSTA, Nashville**
NSTM, Louisville**
Georgia Wildlife Federation conference on outdoor classrooms (four teachers attended)***

* Source: 2006 Spring Team Interview
** Source: Spring 2006 Team Lead Survey
*** Source: Fall 2005 Team Lead Survey

Table 4. NASA (and NASA-affiliated) Resources Used

Robotics*
Mars project*
AES assistance to get the Mars project started; provide teacher workshops; student workshops; science fun nights; and he brought rockets to the school*
KSC NES coordinator arranged for A126 students to attend the "Return To Flight" shuttle launch*
NASA personnel: Met and had lunch with astronaut Sally Ride; met other astronauts at the field center*
Hands-on activities*
Real data to use with students*
Reading materials*
NASA suit*
On-site visits to their NASA field center*
NASA educators and scientists**
Lunar information**
Georgia ecology information**
Imagine Mars-JPL**
Lego Robotics-Mars Adventure**
Mission to Mars-JPL**
KSC Digital Learning Network**

Destination Mars**
Mission to the Red Planet**
Planetary information**
GLOBE program**

*Source: 2006 Spring Team Interview
**Source: NASA Explorer School Digital Portfolios. Retrieved July 20, 2007, from http://aesp.nasa.okstate.edu/efolio

Table 5. NES A126 Math Achievement Scores

Year	Grade	Did Not Meet Standards	Meeting Standards	Exceeding Standards	Number of Students
2003-2004	**1**	14%	63%	23%	87
	2	18%	63%	18%	82
	3	7%	65%	28%	69
	4	19%	74%	7%	69
	5	8%	78%	14%	50
2004-2005	**1**	10%	59%	31%	102
	2	10%	76%	14%	83
	3	3%	65%	32%	104
	4	31%	63%	6%	83
	5	15%	49%	36%	67
2005-2006	**1**	11%	61%	27%	114
	2	26%	65%	9%	103
	3	5%	75%	20%	105
	4	27%	60%	13%	98
	5	13%	63%	24%	79

Source: Georgia Department of Education. (2005-2007). Retrieved March 13, 2007, from http://www.doe.k12.ga.us/

Table 6. NES A126 English/Language Arts Achievement Scores

Year	Grade	Did Not Meet Standards	Meeting Standards	Exceeding Standards	Number of Students
2003-2004	**1**	21%	53%	26%	87
	2	29%	65%	6%	82
	3	12%	48%	41%	69
	4	14%	68%	17%	69
	5	14%	58%	28%	50
2004-2005	**1**	17%	44%	39%	102
	2	14%	53%	33%	83
	3	9%	52%	39%	104
	4	20%	65%	14%	83
	5	9%	52%	39%	67
2005-2006	**1**	23%	68%	10%	114
	2	36%	54%	10%	103
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Source: Georgia Department of Education. (2005-2007). Retrieved March 13, 2007, from http://www.doe.k12.ga.us/

Table 7. NES A126 Reading Achievement Scores

Year	Grade	Did Not Meet Standards	Meeting Standards	Exceeding Standards	Number of Students
2003-2004	**1**	13%	56%	31%	87
	2	37%	43%	21%	82
	3	10%	57%	33%	69
	4	16%	51%	33%	69
	5	22%	48%	30%	50
2004-2005	**1**	17%	44%	39%	102
	2	13%	36%	51%	83
	3	1%	46%	53%	104
	4	23%	53%	24%	83
	5	13%	58%	28%	67
2005-2006	**1**	12%	64%	24%	114
	2	22%	60%	19%	102
	3	16%	67%	17%	103
	4	21%	69%	10%	96
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	5	8%	78%	14%	50
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Source: Georgia Department of Education. (2005-2007). Retrieved March 13, 2007, from http://www.doe.k12.ga.us/

NASA Explorer Schools Case Study Profile: B103
2004 Cohort—Rural, Idaho, Public School: Grades 4-6

Summary Comments Regarding B103
B103 is located in a mountain valley that is transitioning from being primarily a farming community to a suburb of a large city. It is a public intermediate school in Idaho serving a student population of 410 in grades 4-6. The teachers at B103 are proud of their NASA family nights, character education activities, and music program, including a choir, band, and orchestra. B103 has an after-school science program called Discovery Club with a membership of more than 150 students. The student population is primarily Caucasian (around 86 percent) with more than half of students (58 percent) qualifying for free or reduced lunch. B103 has a subgroup of Hispanic students who make up around 11 percent of the student population. Additional details about student population are described in Table 1.

B103 entered the NASA Explorer Schools (NES) program with the objective of increasing student interest and participation in science, mathematics, and technology through involvement with NASA activities. Team members identified steps they believed would accomplish their objective, including providing opportunities for student involvement; connecting science, math, and technology to the real world; upgrading school technology; providing training so that the technology could be used; providing professional development at B103 and throughout their school district; and encouraging family involvement and promoting community support. The B103 team selected mathematical problem solving and technology integration as its top two academic needs to be addressed through participation in the NES project. The team's other seven academic goals to be addressed through NES focused on science standards. More details about B103's top 10 academic needs are provided in Table 2.

Here are some of the successes that B103 achieved during its three-year period as a NASA Explorer School:

- Increases in B103 student scores in state math, language, and reading achievement standardized examinations. Across all three categories B103 students demonstrated significant improvement.
- Increased family participation in school activities.
- As a result of its participation in the NASA Explorer Schools program, the B103 team was invited to participate in the 2006 Governor's Summit on Science, Mathematics, and Technology Education.

- B103 teachers brought their curriculum/standards in line with state standards. Through the sustainability grant they were able to hold three staff workshops to develop a new curriculum map.

As a school that serves a predominantly poor population, B103 faces challenges that compete with STEM-G-related reform activities for teacher and administrator attention. Here are some of these challenges:

- Finding the time to implement the program has been a challenge for the teachers. B103 is working on school improvement issues that go beyond NES activities. The number one issue that emerged from school improvement focus group meetings is what to do about the 40-50 percent of students who are above the minimum competency levels who are getting bored in school because teachers and administration are so focused on those who are at the minimum. While NES may help address this issue, it cannot address all aspects of this school priority.
- The delays in receiving funding have caused some delays in carrying out the implementation plan.

We examined schoolwide achievements at B103 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcript of a focus group interview conducted by telephone with the B103 NES team. The interview was conducted April 18, 2006. We have also used the school website, survey data, NES e-Folio website, and U.S. Department of Education school data to expand upon information provided in the interviews.

Outcome 1: Increased participation and professional growth of educators in science.

The B103 team of four teachers and an administrator report that they have learned to share all communications from NASA with everyone, and this has helped them work well together. The team relies heavily on the technology specialist and tries to help each other. The B103 NES team and its students have participated in a variety of NASA activities, including the NES summer orientation workshop, a national math conference, and the National Science Teachers Association (NSTA) conference. Team members have actively used on-site field center staff, Aerospace Education Specialists, and the Digital Learning Network (DLN) for both professional development for staff and educational opportunities for students. Tables 3 and 4 provide a summary of the professional

development opportunities and NASA resources that B103 has taken advantage of as a NASA Explorer School.

The next section examined the extent to which the B103 school implementation of NES addresses the six guidelines for professional growth and development described below.

Guideline 1. Instructional Strategies.
Teachers reported that getting students engaged in science and technology and improving students' abilities and skills in technology were major goals of their school strategic plan. The plan also included professional development for teachers in science and technology as major goals. When asked how they evaluated the impact of the NES school strategic plan, teachers said, "We see it in everything we do. We do evaluate our strategic plan all the time. [It] is tied to how we view ourselves" (Focus Group Interview, April 18, 2006).

- The NES B103 team has worked with students to conduct the lunar outpost challenge. The teachers are instructed and facilitated by field center staff to adopt an inquiry-based conceptual framework and encourage students to pose questions, research existing studies, design a full or scale model of an Earth-based research station that will support living adaptively and working efficiently on the moon. A copy of one of the school's Lunar Research Station Design projects is posted on the lunar outpost challenge website[1]. This project provides evidence of student immersion in scientific inquiry, questioning, and pre-engineering design concepts.
- The B103 teachers were able to achieve some of their goals for professional development in science and technology through their participation in the National Magnet Lab summer research program. As a participant in Research Experiences for Teachers, one B103 team member was mentored in a six-week study of magnetic suspension and MagLev train technology. A description of the program is posted at www.magnet.fsu.edu. Here is an example of how teachers can fulfill the goal of modeling scientific reasoning and engagement for their students.

In addition to our analyses from the case study, we report some key findings from the survey data on B103. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings.

[1] Source retrieved May 1, 2007, from http://quest.nasa.gov/lunar/outpostchallenge/teachers.html

- When asked how often students in this class do hands-on/laboratory activities, two teachers responded "sometimes," one responded "1-3 times per month," and one responded "1-3 times per week" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often students in this class work in small groups to come up with joint solutions or approaches to a problem or task, two teachers responded "sometimes," one responded "1-3 times per month," and one responded "1-3 times per week" in the TLC survey.
- Here is how teachers responded to questions in the TLC survey regarding how often B103 teachers accomplish the following goals:
    - Elicit students' ideas and opinions: Two teachers responded "often," one responded "very often," and one responded "always."
    - Get students to justify and explain their reasoning: Two out of four teachers responded "often," one responded "very often," and the other responded "always."
    - Have students relate what they are working on to their own experience: Two teachers responded "very often," one responded "often," and another responded "always."
- Three teachers completed the Teacher Need and Involvement survey. When asked how much they anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, one teacher responded "quite a bit," while the other two responded "a little" and "some."

Guideline 2. Time Intensive.

The Teacher Involvement survey was completed by only the B103 team lead. This team member reports attending between "1-5" NASA professional development activities and using between "6-15" NASA activities in his/her classroom during the 2005-2006 academic year.

- As part of the B103 sustainability grant, the B103 NES team was invited to participate in the 2006 Governor's Summit on Science, Mathematics, and Technology Education. The team met with local and state business leaders to promote and sustain the NASA Explorer Schools program. This event also was to gain partnerships with others.
- One B103 team member participated in the National Magnet Lab, which is supported by the National Science Foundation. The lab is the largest program run by any national laboratory and one of only a few programs that include elementary teachers. Teachers are paired with research mentors and spend six hours a day on real-world science investigations. The balance of each day is spent with science educators on strategies for translating their research experiences into classroom materials and

activities for students. Participants are competitively selected for the program and make a strong commitment to being a leader in science education at their school and at their districts.[2]

Guideline 3. Classroom Practices.

B103 team members perceive that their school strategic plan impacts everything they do and "is so tied to how we view ourselves" (April 18, 2006). Along this line, teachers report that they evaluate their strategic plan all the time. The AES serving B103 has been out "to the school pretty often"(Focus Group Interview, April 18, 2006) to help integrate NASA and other STEM-G-related resources into their school curriculum.

- For example, the AES did a training program on the Earth science image processing tool called World Wind that was blended right into the classroom.
- The AES have also helped to develop a group of student specialists at the school who received special training and who also help implement the program schoolwide. The student specialists attend a monthly meeting that focuses on a particular challenge. The students learn about this challenge and present what they learned back in their classes using background information, overheads, etc. "For example, one of the challenges was to design a nano-robot that could perform certain functions. Once the student specialists had done this challenge and created a nano-robot, they presented this to other classes" (Focus Group Interview, April 18, 2006).
- The NES B103 team has worked with students on the lunar research station design challenge, which requires students to use NASA sites on Earth to simulate living and working on extraterrestrial surfaces, and to build a full or scale model of an Earth-based research station that will support living adaptively and working efficiently on the moon.[3]
- "This program has given me chances to do things that I never would have been able to experience. It is great to bring it back to the classroom and see the students' eyes light up" (Focus Group Interview, April 18, 2006).

Guideline 4. Content Knowledge.

Teachers reported that participating in NES has raised student esteem about science to the point that students have initiated correspondence with scientists,

[2] Source retrieved May 1, 2007, from http://www.magnet.fsu.edu/
[3] Source retrieved May 1, 2007, from http://quest.nasa.gov/lunar/outpostchallenge/

and a teacher said, "Scientists actually used one of the design ideas that our students had" (Focus Group Interview, April 18, 2006).

- The student teacher working with the B103 NES project said, "The NES program has provided a ways for us to get…training.…[It's been] an eye opener to new science curriculum" (Focus Group Interview, April 18, 2007) and extracurricular activities.
- Another B103 team teacher described how this program has impacted her personally: "The NES has generated so much interest in science, and science clubs…this has been phenomenal for me" (Focus Group Interview, April 18, 2007).
- Five teachers have been trained to use the 3-D View program. They piloted the program with their fifth and sixth grade classes.

Guideline 5. Active learning.
The B103 team has a set time for weekly team meetings.

- As indicated by the field center staff, the field center provides in-house services for NES B103, and a lot of services are face-to-face, which seem to be more efficient and effective for the teachers.

Guideline 6. Coherence.

- In February 2007 teachers worked on getting their curriculum/standards in line with the state's. B103 is getting new math and science curriculum, plus there is a real need to align our curriculum to our state standards. Through the sustainability grant the team held three sessions of staff workshops to help develop this curriculum map.
- B103 teachers met with experts in math and language arts in order to map out the curriculum for grades 4-6.

Summary of How B103 Meets Outcome 1.
The NES B103 team has initiated several STEM-G activities provided by NASA. The team has worked hard to improve teaching methods and strategies to increase students' math and science scores. The participation in the lunar challenge has been an outstanding experience for teachers and students. B103 teachers are able to align the activities with state standards. Additional grants also provide teachers more resources to develop coherent curriculum plans.

Outcome 2. Increased assistance for and technology use by educators in schools with high populations of underserved students.

Improving the school technology and improving students' abilities and skills with technologies were key goals in the B103 school strategic plan. Team members felt that they were lacking in technology resources and, as a result, in technology education areas. Once its videoconferencing system was in place, B103 has been using it to support professional development activities. Some of its DLN sessions for professional development include Simple Machines, Signals of Spring (fall 2005), Althura, and Nemo. The school plans to hook up with Kennedy Space Center for its upcoming family night.

The B103 team purchased the following technologies with NES funding:

- Videoconferencing equipment
- LabPro JASON activities package
- T1 Graphlink cable
- Interactive SmartBoard

In October 2006 the Governor's Summit on Science, Mathematics, and Technology Education brought together government officials, educators, and businesspeople from around Idaho to discuss ways for business and educators to assist each other in reaching common goals. Participants discussed needs and how to meet them for both groups. For instance, how can businesses reach out and support schools? And what does business need in the way of training for its future workers.

On March 1, 2007, during the school day and at family night, the school had a videoconference down link with regional NASA field center through the DLN.

The NES evaluation team also collected and reported the data from Teaching, Learning, and Computing (TLC) and Teacher Need and Involvement surveys to generate a more inclusive picture of how B103 teachers integrate technology. When teachers were asked how many days a year a typical student in the class uses a computer while they are teaching their class, teachers responded only "11-20 times" a year. Teachers also responded only "16-30 times" for using NASA materials in their classroom in a year.

Outcome 3. Increased family involvement in children's learning.

Increasing parental involvement was a major motivation for B103 teachers applying to the NES project. B103 has helped keep families and the community involved and informed about their involvement in the NES project through their website. Family nights are posted along with other school activities on the web,

and families can also view NASA activity and information links. The school website includes a parental involvement page with recommendations for parental involvement and access to student educational goals by grade. The B103 team helped another local school not involved in NES implement a family science night.

- "At the first family night, we had over 400 participants. The school population is only 410. We have the PTO helping, Lions Club helping, using videoconferencing for professional development on simple machines. We had Signals of Spring training last fall, and they are implementing it now at the school. This training was done via teleconferencing. We will hook up with Kennedy for our next family night" (Focus Group Interview, April 18, 2006).
- "Last year we had the session with SEMA….We did a videoconference event with them and it did not go over particularly well....They felt that the activities were a little bit juvenile"
- "This year a lot of the schools have had very successful family nights, and I've been there for several of them. I've participated in two of them, and I think that I have seen in several instances some great success and heard stories from other schools that I didn't personally see about the great success that they had with family involvement as far as having an evening where the community and the families were invited to attend. So we're going to go out to another site, and we're going to have a little general talk of family involvement, but then we're going to get very specific because a lot of the schools like to have a star party. Having a star party, having some telescopes to look at the night sky, is a really good way to get people enthusiastic about science and enthusiastic about what their kids are getting out of their science or math classes" [4]

In searching for information on family involvement in B103, we found the following postings on the NES e-Folio website:

- In October 2006, 421 students and 15 families participated in the Paper Airplane Challenge. This is our schoolwide challenge to build excitement about our Celebration of Flight NASA Family Night Nov. 8th. Students are asked to design a paper airplane using only 1 piece of paper. If it's able to land in a designated landing strip, they will win a small award. The classes will vote on the best decorated and designed plane that will be put on display during family night, plus given an award. Each class will have a winner.

[4] Excerpt from Field Center Staff interview, Spring, 2005.

- NASA Family Fun Night will take place in November 2006. We will be celebrating our 3rd year as a NASA Explorer School. The topic of flight will be introduced in our classroom prior to our Family Night. Tony Levitt will put on an assembly to excite students about the family night. He will also be meeting with teachers. We have invited community members to do presentations on flight and careers involving flight.
- On March 1, 2007, the second Family Fun Night occurred. Our music teachers were involved in exploring sound and sound waves with our students. The event began with a hook-up and congratulations from Dryden to our first and second place winners in their 60th anniversary competition. Our winning challenge team presented their NASA rap. Then families visited five stations to learn all about sound. We ended the evening with everyone coming together to play Twinkle, Twinkle Little Star on PVC pipes and do the rainforest, complete with thunder and lightning.

Outcome 4. Increased student interest and participation in STEM-G.

The B103 school e-Folio outlines activities that allow students to participate in STEM-G practices and discourse—for example, viewing through a 3-D program and the lunar challenge activity. In the latter students were required to engage in scientific inquiry process to make predictions, present hypotheses, conduct experiments, and research information for coming up with valid solutions.

The following strands are indicators of what it means for students to have interest and to participate in STEM-G activities. Students who are interested and participate in STEM-G activities have the tendency to:

Participate productively in STEM-G practices and discourse.

- As documented in the NES e-Folio, 150 students participated in the 3-D View activity. 3-D View is a program that uses 3-D glasses to look at geology, ecosystems, atmosphere, biosphere, etc. It is an exciting program that brings technology, literature, and research together in an exciting way for students (October 2006).
- In the NES e-Folio students participated in a lunar challenge activity. Sixty students were challenged to design a habitat for living on the moon. They needed to research the needs of astronauts who would be living and building permanent settlements on the moon. Then they designed and created a model of the habitat. Along with this they also needed to write a description and reasons for their design and choice of where to locate it.

Attitude change about learning.

> "As a small rural community, an over the hill kind of school, this program has given the school something to be special about. It has raised student esteem about science" (Focus Group Interview, April 18, 2006).

Active participation in hands-on and authentic scientific research.

- B103 participated in the ISS/Space Camp Competition. Eleven students were chosen to ask the astronaut questions. This event has excited many students in STEM-G subjects. Along with getting the chance to question the astronaut, two lucky students were selected to go to Space Camp in July. They developed a project-based activity answering a big question about the ISS and presented this project to a panel of three judges, who choose the winners based on the quality of their project and presentation.
- B103 had a schoolwide challenge to design a paper airplane capable of landing in a designated area while having a cool design too.

Outcome 5. Increased student knowledge about careers in STEM-G.

B103 students were invited to apply for the position of NASA student specialist. These students were excited to be able to work with astronauts and ask questions directly. This gives them a sense of reality and boosts their enthusiasm for STEM-G careers.

The following strands indicate students' knowledge about careers in STEM-G. Students who demonstrate knowledge about careers in STEM-G also demonstrate:

Increased understanding and enthusiasm about STEM-G careers.
As indicated in the NES e-Folio website, 20 students in grades 5-6 are invited to apply for the position of NASA student specialist. They are given training in teamwork. Their job is to present NASA activities challenges to the student body. They also help at NASA family nights. In December fourth grade NASA specialists will be added to the group. The NASA lead test pilot congratulated two B103 students on their winning entries in the Dryden anniversary competition and gave some background into what it's like to be a NASA test pilot.

Outcome 6. Increased student ability to apply STEM-G concepts and skills in meaningful ways.

NASA activities are targeted for students to participate in problem-solving processes. Students constantly apply their STEM-G concepts and skills in different contexts. As a result, B103 school has observed an increase in students' achievement scores in math and reading.

Understand and use scientific explanations of the natural world in context of a problem-solving activity.
As documented in the NES e-Folio, B103 has proposed several activities that involve students in problem solving:

- In January 2007 students will participate in the Mystery Class activity. There are 10 "Mystery Classes" hidden around the world. The changing amount of sunlight at each site is the central clue. Students will discover the locations of the Mystery Classes by recording their local sunrise and sunset every week and comparing it to the Mystery Classes'. The last six postings will reveal other clues to the mystery locations.
- In February 2007 students will participate in the cloud challenge. Students will research a variety of clouds and pick their favorite. They will make a picture of the cloud, write its description, and then turn the picture with description into a puzzle. Our NASA student specialists will judge the puzzles, picking the best from each classroom.
- In March 2007 DLN America's Spaceport Kennedy Activity occurred. Students were asked to do some research into Kennedy Space Center's history, study the math involved in the sizes of various parts of launching a shuttle, and develop questions about the space center they didn't find during their study of it.

Understand how to use and interpret the data obtained from technology tools to support STEM-G-related inquiry activities.

- In August 2006 student specialists were challenged to research and make posters and essays celebrating Dryden's 75th anniversary. Twelve of them participated. Eight met all the criteria of the competition and were sent to Dryden. It was a great beginning challenge for the selected NASA student specialists.

Evidence is available to demonstrate student performance increased in STEM and related subjects like language arts.
B103 teachers said, "Scores are definitely part of what we look at. This year [spring 2006] we're feeling pretty darn good about it. After doing Signals of Spring, NASA said this activity would really improve our students' math scores"

(Focus Group Interview, April 18, 2006). Tables 5-7 illustrate the changes in B103 student scores in state math, language, and reading achievement standardized examinations. Across all three categories, B103 students demonstrated significant improvement.

Specifically in math, a subject targeted by many of the NASA Explorer Schools interventions, B103 has achieved success at all grade levels. Grade 4 scores are available from prior to inception of the NES program at B103. In 2003, 50.69 percent of grade four students were considered proficient or advanced in math. This number has jumped to 96.1 percent as of 2006. Specifically looking at the category of advanced, B103 grade four students have jumped from 4.11 percent to 38.6 percent. Scores for grades five and six are available only from 2005 and 2006, yet they also show gains in math. B103 grade five students have moved from 70.97 percent to 85.4 percent proficient or advanced in math. B103 grade six students have moved from 69.5 percent to 89.7 percent proficient or advanced in math. Again, specifically looking at the advanced category in math, grade five has jumped from 15.32 percent to 29.9 percent, and grade six has jumped from 5.67 percent to 29.4 percent.

B103 has implemented the NASA Explorer Schools program throughout its curriculum. Evidence of this can be seen in many B103 activities, including:

- Dryden 60-year anniversary: Students researched and designed a poster and wrote an essay celebrating Dryden's anniversary.
- Name ISS Node 2 Challenge: Students design a classroom-size model of ISS Node 2. They submit a name, an essay about their choice of name, and a digital tour of their Node 2.
- NASA student specialists: Students are trained to be NASA specialists and present NASA challenges to the student body.

Table 1. School Demographics

	2002-2003	2003-2004	2004-2005	2005-2006
Student Population	467	409	401	
Black, non-Hispanic	5	6	6	
Asian	6	6	6	
Hispanic	67	47	43	
Indian, Alaskan Native	0	3	2	
White, non-Hispanic	389	347	344	
School Location (rural, suburban, urban, large central city)	Rural	Rural	Rural	
School Type (public, private, charter, magnet)	Public	Public	Public	
Title 1 status (yes or no)	Yes	Yes	Yes	
English Language Learners				8%
Free and Reduced Price Lunch	61%	63%	56%	58%
Teacher Population	21.5	20.2	19.9	

Note: Grayed-out cells indicate that data is not available as of March 14, 2007.

Source: Idaho State Department of Education. (2003-2007). Retrieved March 13, 2007, from http://www.sde.idaho.gov/dept/
Source: *CCD Public school data 2004-2005 school year*. Institute of Education Sciences (IES), U.S. Department of Education National Center for Education Statistics. (2004-2005). Retrieved March 13, 2007, from http://nces.ed.gov/ccd/schoolsearch/school_detail.asp?Search=1&SchoolID=130231003049&ID=130231003049

Table 2. Summary of Academic Needs Identified by B103 in 2004*

Priority	Discipline	Category	National Standard
1	Principles and Standards for School Mathematics	Problem Solving	Apply and adapt a variety of appropriate strategies to solve problems
2	National Educational Technology Standards		Select and use appropriate tools and technology resources to accomplish a variety of tasks and solve problems.
3	National Science Education Standards	Physical Science	Properties and changes of properties in matter
4	National Science Education Standards	Earth and Space Science	Earth in the solar system
5	National Science Education Standards	Life Science	Structure and function in living systems
6	National Science Education Standards	Life Science	Diversity and adaptations of organisms
7	National Science Education Standards	Physical Science	Motions and Forces
8	National Science Education Standards	Life Science	Populations and ecosystems
9	National Science Education Standards	Earth and Space Science	Structure of the Earth system
10	National Science Education Standards	History & Nature of Science	Science as a human endeavor.

Source: B103 Needs Assessment. (2004).

Table 3. NASA Professional Development Opportunities That B103 Teachers Completed

NES summer orientation workshop*
NSTA***
National Math Conference***
National Science Conference****

*Source: Spring 2006 Teacher Involvement Survey
**Source: Fall 2004 Team Lead Survey
***Source: Spring 2006 Team Lead Survey
****e-Folio

Table 4. NASA (and NASA-affiliated) Resources Used

Visits from field center staff**
Curriculum materials
Distance Learning Network
AES staff

* Source: Spring 2006 Team Lead Survey
**Source: Fall 2004 Administrator Survey

Table 5. NES B103 Math Achievement Scores

Year	Grades Tested	Below Basic	Basic	Proficient	Advanced
2003	4	8.9	40.41	46.58	4.11
2004	4	0.88	21.05	64.04	14.04
2005	4	3.17	6.35	52.38	38.1
2005	5	8.06	20.97	55.65	15.32
2005	6	2.13	28.37	63.83	5.67
2006	4	0	3.9	57.5	38.6
2006	5	0	14.6	55.5	29.9
2006	6	0	10.3	60.3	29.4

Source: Idaho State Department of Education. (2003-2007). Retrieved March 13, 2007, from http://www.sde.idaho.gov/dept/

Table 6. NES B103 Language Achievement Scores

Year	Grades Tested	Below Basic	Basic	Proficient	Advanced
2003	4	7.09	24.11	51.77	17.02
2004	4	1.75	12.28	50.88	35.09
2005	4	5.56	19.84	36.51	38.1
2005	5	13.71	12.9	50.81	22.58
2005	6	7.8	14.18	49.65	28.37
2006	4	0.8	6.3	43.3	49.6
2006	5	2.2	19.7	50.4	27.7
2006	6	6.3	15.9	51.6	26.2

Source: Idaho State Department of Education. (2003-2007). Retrieved March 13, 2007, from http://www.sde.idaho.gov/dept/

Table 7. NES B103 Reading Achievement Scores

Year	Grades Tested	Below Basic	Basic	Proficient	Advanced
2003	4	11.64	29.45	37.67	21.23
2004	4	4.24	17.8	44.07	33.9
2005	4	1.59	15.08	46.83	36.51
2005	5	10.48	19.35	47.58	22.58
2005	6	5.67	10.64	60.99	22.7
2006	4	2.4	7.1	36.2	54.3
2006	5	1.45	13.77	44.2	40.58
2006	6	1.57	18.11	47.24	33.07

Source: Idaho State Department of Education. (2003-2007). Retrieved March 13, 2007, from http://www.sde.idaho.gov/dept/

NASA Explorer Schools Case Study Profile: C103
2004 Cohort—Urban, Michigan Public Elementary School: Grades PK-5

Summary Comments Regarding C103
C103 is an elementary school in a large central city in Michigan. This school was selected as a NASA Explorer School in 2004. The student population was 714 students in the 2003-2004 school year and decreased to 617 students in 2004-2005. The percentage of students receiving free or reduced lunch increased from 77 percent to 99 percent from the school years 2003-2004 to 2004-2005. See Table 1 for more information on the school demographics.

Here are some of the successes that C103 achieved during its three-year period as a NASA Explorer School:

- The technological tools the school purchased through NES have been a great help on the family nights.
- C103 has also received other grants to complement the NASA grant. C103 received a Convergence Education Foundation—Technology Rich Education for Kids (CEF-TREK)[1] grant, which provided support for an after-school ham radio club; an Air Force Association Grant for building model rockets; and a 21st Century Learning Grant for an after-school tutoring and enrichment program.

As a school that serves a predominantly poor population, C103 must overcome challenges that compete with STEM-G-related reform activities for teacher and administrator attention. Here are some of these challenges:

- Unresolved technical problems and lack of on-site technical support have not allowed NES C103 to progress according to schedule.
- The team has been struggling with finding a common time for team meetings. Not being able to meet regularly has produced some chaos within the team.

We examined schoolwide achievements at C103 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcripts of one focus group interview conducted by telephone with the C103 NES team. The interview was conducted May 1, 2006. We have also used the school website, survey data, NASA Explorer Schools e-Folio website, and U.S. Department of Education school data to expand upon information provided in the interviews.

[1] The CEF-TREK funding is a state-based initiative designed to support engineering, math, and science education and aligns well with NES goals. Find out more at www.cef-trek.org.

Outcome 1. Increased participation and professional growth of educators in science.

The C103 team consists of an administrator who is a first-year principal and a team lead who is a teacher. The administrator is also a facilitator. She said, "If there is a problem, I pull them in to talk about it, provide encouragement, and make things happen. The team is a little agitated because they are high-achieving individuals, and they want things to be perfect the first time around. Our team members were busy and supportive in the NASA blastoff. We wanted every grade level to do a parent night. Each grade has provided an activity to build the science and math program. Three times this month we will meet to provide activities for parents and students to do outside of the school setting" (Focus Group Interview, May 1, 2006). In 2007 the C103 team lead received the state teacher of the year award from the Air Force Association. Tables 3 and 4 provide a summary of the professional development opportunities and NASA resources that C103 has taken advantage of as a NASA Explorer School.

The next section examined the extent to which the C103 school implementation of NES addresses the six guidelines for professional growth and development described below.

Guideline 1: Instructional Strategies.
The team administrator said that "the program has provided new skills and exposed other teachers to additional instructional materials" (Focus Group Interview, May 1, 2006). The administrator also reported that two non-team members attended one of the NASA-sponsored professional development conferences, and the administrator said that the participants "got a lot out of those experiences" (Focus Group Interview, May 1, 2006).

The C103 team lead attended the Winter Story workshop offered at Yellowstone National Park, which allowed the teachers to be immersed in scientific inquiry while they learned strategies to "to infuse new ideas for teaching weather into our curriculum…" And as this teacher further reports, attending this workshop allowed her to bring back "ideas for other teachers and knowledge of ecosystems, weather, and climate changes. Students have set up a weather station and have been entering weather data on the Winter Story website."[2].

In addition to our analyses from the case study, we report some key findings from the survey data on C103. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings.

[2]http://aesp.nasa.okstate.edu/efolio/

- When asked how often students in this class do hands-on/laboratory activities, three teachers responded "sometimes," one responded "1-3 times per month," and one responded "1-3 times per week" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often students in this class work in small groups to come up with joint solutions or an approach to a problem or task, two teachers responded "1-3 times," two responded "1-3 times per week," and one responded "sometimes" in the TLC survey.
- Here is how teachers responded to questions in the TLC survey regarding how often C103 teachers accomplish the following goals:
    - Elicit students' ideas and opinions: Two teachers responded "very often," one responded "always," one responded "often," and one responded "never."
    - Get students to justify and explain their reasoning: Two out of five teachers responded "always," two responded "very often," and one responded "often."
    - Have students relate what they are working on to their own experience: Two teachers responded "always," two responded "very often," and one responded "never."
- From the Teacher Need and Involvement survey on how much they anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, three teachers responded "quite a bit," two responded "some," and one said "not at all."

Guideline 2: Time Intensive.
When C103 teachers participated in professional development, they committed time both during the workshop and to implementation of what they learned afterward. Teachers report that "professional development is the greatest component of the program. Sending teachers to conferences and sending people to help at our school are also good" (Focus Group Interview, May 1, 2006). Here are examples of C103 comments about professional development workshops, conferences, and satisfaction with this component of NES:

- One of the C103 teachers attended the Winter Story workshop and brought back ideas for other teachers about ecosystems and climate changes….After returning, students completed an entire weather unit. The teacher reports that 30 teachers, 180 K-8 students, and one administrator participated in activities resulting from this professional development experience.
- In May 2007students built and launched rockets from Estes kites, but before then the teachers selected NASA activities off the website, such as the Paper Rocket activity to prepare students for the rocket launching.
- "Professional development days were valuable. The NASA field center education specialist was readily available to help us. He came to provide

professional development and supplied resources" (Focus Group Interview, May 1, 2006).

Guideline 3: Classroom Practices.
C103 used its NASA Days to promote interest in two schoolwide Earth science theme days. Teachers explain how they have planned ways to involve all teachers and stimulate student interest by providing all teachers with NASA lessons and ideas to engage the students. They said, "Announcements with space facts will reinforce the schoolwide theme, a raffle for some rockets, and NASA materials will excite students, and everyone will be immersed in NASA activities"[3].

In the telephone interview with the C103 team, team members described how NASA professional development opportunities and resources have impacted their teaching strategies and changed the kind of materials they use in their instruction:

- "[NES] provides new skills and exposes [non-NES teachers] to additional instructional materials" (Focus Group Interview, May 1, 2006).
- "One of the team members is doing something with robotics as a result of a convergence grant. Two teachers are sharing their math expertise. We are working toward including NASA materials in the curriculum. I am looking to include it with my K-3 students to provide a background" (Focus Group Interview, May 1, 2006).

Guideline 4: Content Knowledge.
This comment from the C103 team administrator shows how the program benefits both administrators as well as teachers through opportunities to improve their content knowledge and confidence in STEM areas: "The program has helped me become more comfortable with science and math. It has provided professional development (San Antonio administrators' meeting). I had a chance to share ideas with other administrators. It is helping me grow as a professional" (Focus Group Interview, May 1, 2006).

This entry by the C103 team on its digital portfolio gives some insight into how teachers absorb what they are exposed to via NES training both off site and at their school to integrate new content and activities. When asked to describe what NASA materials they have used, teachers responded that they use "lessons we have seen in the past provided by [our AES as well as] technology purchased via NASA funds"[4]

[3] http://aesp.nasa.okstate.edu/efolio
[4] http://aesp.nasa.okstate.edu/efolio

Guideline 5: Active Learning.
As documented in their digital portfolio, the C103 teachers have found ways to use NASA and other national and regional partner resources to help them address their academic goals for their students. Their primary goals as defined in their NES digital portfolio are to increase student abilities, knowledge, and interests in STEM-G topics and careers. They have identified these six content areas to address through NES and other partnership professional development experiences:

- Changes in Earth and sky
- Motions and forces
- Organization and consolidate their mathematical thinking through communication
- Position and motion of objects
- Transfer of energy
- Use content-specific tools, software, and simulations to support learning and research

Here are some additional examples of how C103 teachers became engaged in meaningful discussions, planning, and practices regarding how to meet standards of learning goals through new STEM-G resources made available through NES:

- The C103 team lead attended the Winter Story workshop and brought back ideas for other teachers and knowledge of ecosystems, weather, and climate changes. Students have set up a weather station and have been entering weather data on the Winter Story website. After returning, students completed an entire weather unit.[5]

Guideline 6: Coherence.
The weather station activities gained by the C103 team lead attending the Winter Story workshop were shared with a middle school[6]. The C103 team has successfully leveraged NES funding to pursue additional partnerships and funding. Here are several examples.

- The team lead said, "The program allows me to network at the conference. As a result, I got a convergence grant" (Focus Group Interview, May 1, 2006).
- "Last year and continuing into this year we have received many grants to complement our NASA grant. We have a CEF grant for an after-school ham radio club, an Air Force Association grant for building model rockets. and a 21st Century Learning grant for a wonderful after-school tutoring

[5] Source retrieved April 30, 2007, from http://aesp.nasa.okstate.edu/efolio/
[6] efolio:http://aesp.nasa.okstate.edu/efolio

> and enrichment program. This year we will continue to hold family nights and events. We hope to have NASA days at least twice this year to get all grade levels involved. We plan to continue using NASA lessons off the website and get our new videoconferencing system up and working so we can plan at least two or three video conferences this year.[7]"

Summary of How School Meets Outcome 1.
The school administrator has been playing a supportive role toward the program. She supports teachers to attend professional development workshops and training and encourages them to adopt new instructional strategies and materials in the classrooms. The program has helped the administrator and teachers to gain leadership skills and competence toward science. The school later received other grants to enrich its after-school tutoring program.

A question that emerges from analysis of the professional development data is how does the improvement documented here in teacher professional development experiences and teacher growth impact overall school climate and ultimately student learning and performance? The next sections will look at additional data to try to address this question.

Outcome 2. Increased assistance for and technology use by educators in schools with high populations of underserved students.

The C103 school expresses these goals for integrating technology through NES support: "We plan to continue using NASA lessons off the website and get our new videoconferencing system up and working so we can plan at least two or three video conferences this year" (http://aesp.nasa.okstate.edu/efolio). The C103 team purchased the following technologies with NES funding:

- Laptops
- Videoconferencing equipment
- Printers
- Digital projector
- Camcorder
- Robotics

"We purchased videoconferencing equipment. We have used our technical purchases (five laptops, printer, digital projector, and camcorder) in the classrooms" (Focus Group Interview, May 1, 2006).

[7] Source retrieved April 30, 2007, from http://aesp.nasa.okstate.edu/efolio

"The major problem has been getting the wiring done for videoconferencing. The problem has been working through our system, not NASA. I am pleased to have the computers available for classroom use because our computer lab is not yet available" (Focus Group Interview, May 1, 2006).

The NES evaluation team also reported the data from Teaching, Learning, Computing (TLC) and Teacher Need and Involvement surveys to generate a more inclusive picture of how C103 teachers integrate technology. When teachers were asked how many days a year a typical student in the class uses a computer while they are teaching their class, teachers responded only "1-5 times" a year. Teachers also responded only "6-15 times" for using NASA materials in their classroom in a year.

Outcome 3. Increased family involvement in children's learning.

NES teachers at C103 are motivated to continue the NASA days and family activities that they have initiated thus far as a NASA Explorer School. As this quote from their e-Folio profile explains, "This year we will continue to hold family nights and events. We hope to have NASA days at least twice this year to get all grade levels involved[8]." Below are descriptions of family activities initiated at C103.

- "We had a family night (which brought the community in as well) and have newsletters going out to parents" (Focus Group Interview, May 1, 2006).
- "Parent night occurs twice each month and helps us meet the Michigan Education Association Program standards. We had a parent night with about 76 participants. The next family night we had about 150 parents participating" (Focus Group Interview, May 1, 2006).

Searching for postings about C103 outreach and family events on the web, we found the following comment from the parent of a C103 student who is concerned about students' discipline and lack of technology within the school.

> "This school has many students with behavior problems, and the administration is weak and flip-flops on issues. The classrooms have no computers or televisions. Most of the teachers try, but there is little parent support" (Focus Group Interview, May 2005).

Outcome 4. Increased student interest and participation in STEM-G.

[8] July 15, 2007: http://aesp.nasa.okstate.edu/efolio

C103 NES teachers have observed that students' participation toward STEM-G have increased, and students are more likely to ask science-related questions. Teachers expressed a lot of changes in students have to do with NES program.

The following strands are indicators of what it means for students to have interest in and to participate in STEM-G activities. Students who are interested and participate in STEM-G activities have the tendency to:

Participate productively in STEM-G practices and discourse.
The NES C103 team lead attended Winter's Story at Yellowstone National Park. "The activities and ideas I found there were wonderful. Upon returning, my fourth grade did an entire unit on weather and really got an opportunity to study weather and think like scientists" (Focus Group Interview, May 1, 2006). Student weather data collected from the school weather station was posted online from December 2006 through February 2007

Noticeable curiosity in STEM-G topics and events.
"They are more anxious to do scientific activities. I see them with GM engineers who come to help them do projects. They are excited about after-school activities. They behave so well because they want to be able to participate" (Focus Group Interview, May 1, 2006).

Active participation in hands-on and authentic scientific research.
As documented in NES e-Folio, students attend the Department of Defense program called STARBASE. Students launch rockets, fly a flight simulator, watch movies about space, hear guest speakers, and gain a great deal of knowledge about Earth science and physics.[9]

Outcome 5. Increased student knowledge about careers in STEM-G.
Teachers report that participation with various NASA activities have changed how students have viewed themselves, and data to support their observation is provided in the subtopics below.

The following strands indicate students' knowledge about careers in STEM-G. Students who demonstrate knowledge about careers in STEM-G also demonstrate:

Changes in self-identity.
"They can see themselves in science careers now" (Focus Group Interview, May 1, 2006).

[9] Source retrieved April 30, 2007, from http://aesp.nasa.okstate.edu/efolio/

Outcome 6. Increased student ability to apply STEM-G concepts and skills in meaningful ways.
C103 e-Folio documented activities students will participate in. These activities are intended to let students apply their STEM knowledge and skills in the real problem contexts.

Understand and use scientific explanations of the natural world in context of a problem-solving activity.
After learning about rockets and building them from kits, students will launch them and discuss distance, trajectory, and NASA careers and rocketry.

Understand how to use and interpret the data obtained from technology tools to support STEM-related inquiry activities.

The students will learn about and build electronic kits. Students have researched and purchased a ham radio and hope to apply to communicate with the ISS. This program is funded by the Convergence Education Foundation.

Demonstrate increased student performance in STEM and related subjects like language arts.
"I have seen the MEAP science test scores go up. It is part of our school goals" (Focus Group Interview, May 1, 2006).

Table 1. School Demographics

	2002-2003	2003-2004	2004-2005	2005-2006
Student Population	939*	714*	617*	
Black, non-Hispanic	936*	712*	614*	
Asian	0*	0*	0*	
Hispanic	0*	0*	0*	
American Indian, Alaskan Native	0*	0*	1*	
White, non-Hispanic	3*	2*	2*	
School Location (rural, suburban, urban, large central city)	Large city*	Large city*	Large city*	
School Type (public, private, charter, magnet)	Public*	Public*	Public*	
Title 1 status (yes or no)			Yes*	
English Language Learners				
Free and Reduced Price Lunch	71%*	77%*	99%*	
Teacher Population	32*	34*	37*	

Note: Grayed-out cells indicate that data is not available as of March 14, 2007.

Source: *Common Core of Data (CCD), "Public Elementary/Secondary School Universe Survey" , 2002-03 v.1a, 2003-04 v.1a, 2004-05 (Preliminary) v.0f-preliminary*. National Center for Education Statistics (NCES). (date not provided). Retrieved March 14, 2007, from http://nces.ed.gov/

Table 2. Summary of Academic Needs Identified by C103 in 2004*

Priority	Discipline	Category	National Standard
1	National Science Education Standards	Earth and Space Science	Structure of the Earth system
2	National Science Education Standards	Earth and Space Science	Changes in Earth and sky
3	National Science Education Standards	Physical Science	Motions and Forces
4	Principles and Standards for School Mathematics	Communication	Organization and consolidate their mathematical thinking through communication
5	Principles and Standards for School Mathematics	Communication	Use the language of mathematics to express mathematical ideas precisely
6	Principles and Standards for School Mathematics	Measurement	Understand measurable attributes of objects and the units, systems, and processes of measurement
7	National Science Education Standards	Physical Science	Position and motion of objects
8	National Science Education Standards	Physical Science	Transfer of Energy
9	National Educational Technology Standards		Use content-specific tools, software, and simulations to support learning and research.
10	National Science Education Standards	Life Science	Populations and ecosystems

Source: C103 Needs Assessment. (2004).

Table 3 NASA Professional Development Opportunities That C103 Teachers Completed

NES summer orientation workshop***
NSTA (two teachers)**
National Math Conference (two teachers)**
Administrators' conference, San Antonio, TX (one administrator)**
Summer in-services*
Nashville conference*
Presented at a Michigan Science Teacher Association Conference, Lansing, MI*

* Source: 2006 Spring Team Interview
** Source: Spring 2006 Team Lead Survey
*** Source: Fall 2005 Team Lead Survey

Table 4 NASA (and NASA-affiliated) Resources Used

Use of NASA content and curriculum to enhance learning***
Aerospace curriculum**
Professional development*
AES support*
NES coordinator support*

* Source: 2006 Spring Team Interview
** Source: Spring 2006 Team Lead Survey
*** Source: Fall 2005 Team Lead Survey

Table 5. C103 MEAP Grade 3 Scores

	Reading	Writing	Math
2006	74%	52%	73%
2007	66%	37%	54%
State Average in 2007	87%	52%	88%

Source: MEAP Results. (2006-2007). Michigan Dept. of Education. Downloaded May 3, 2007, from http://www.michigan.gov/mde/

Table 6. C103 MEAP Grade 4 Scores

	Reading	Writing	Math
2006	54%	46%	52%
2007	55%	25%	49%
State Average in 2007	85%	45%	85%

*Source: MEAP Results. (2006-2007). Michigan Dept. of Education. Downloaded May 3, 2007, from http://www.michigan.gov/mde/

Table 7. C103 MEAP Grade 5 Scores

	Reading	Writing	Math	Science
2006	49%	37%	46%	41%
2007	64%	31%	37%	52%
State Average in 2007	84%	57%	76%	83%

Source: MEAP Results. (2006-2007). Michigan Dept. of Education. Downloaded May 3, 2007, from http://www.michigan.gov/mde/

NASA Explorer Schools Case Study Profile: D109
2004 Cohort—Urban, California, Public Magnet Elementary School: Grades K-5

Summary Comments Regarding NES D109
D109 is an elementary magnet school on the urban fringe of a large city in California. This school was selected as a NASA Explorer School in 2004 to accommodate its multilingual and multiethnic community and to improve the school's academic performance in core subject areas. The overriding theme for D109 has been the improvement of student education in math and science supported by the integration of technology. The student population has remained relatively steady, with an increase of 33 students between the school years of 2002-2003 to 2004-2005. The percentage of students receiving free or reduced lunch increased from 27 percent to 34 percent from 2002-2003 to 2004-2005. See Table 1 for more information on school demographics.

Below are highlights of accomplishments that D109 achieved during its three-year period as a NASA Explorer School:

- D109 successfully carried out special events encouraging parental involvement, such as family astronomy and science nights. The team is intact, including all of the original team members, and continues to be enthusiastic and actively engaged in being a part of NASA Explorer Schools.
- In 2007, D109 received the Educator Grant from the Air Force Association to promote aerospace education activities. D109 continues to seek out external funding and sustains professional development through multiple sources.
- The partnership with NES has allowed D109 teachers to attend videoconferencing equipment training so that they can integrate more DLN programs into the curriculum.
- The AES and field center staff have been instrumental when it comes to professional development and promoting student learning. Experts come to the school to speak with students and parents and to model inquiry activities for the teachers.
- The team has successfully built partnerships with other NES schools and credits these connections with having greatly impacted the school and students.
- The percentage of students in the advanced category in mathematics increased from 2003 to 2006 for grades 2, 3, and 4. Also, the percentage of students in grades 1-5 scoring in the advanced category increased in that period too. A lower percentage of students in grades 2-3 scored in the far below basic standards from 2003-2006 as well.

Here is a summary of challenges that have affected D109's NES implementation:

- D109 team members said getting the money on time for the school to implement its plans has been challenging. Use of the money is limited in terms of materials that teachers can purchase for parents nights.
- Scheduling team meetings has been difficult because of trying to find a common time when every member of the team is available to discuss activities.
- Some NASA activities are time-consuming to implement. With teachers pressured to get their test scores up, their schedules were packed with fulfilling state and school requirements. Most of the time, NASA activities are being pushed aside.
- The entire school did not have the same access to types of technology. For example, NASA resources are very limited for grades K-3, grades and the technology support is inconsistent between across grade levels.

We examined schoolwide achievements at D109 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcripts of a focus group interview conducted by telephone May 25, 2006, with the D109 NES team. We have also used other resources, such as the school website, e-portfolio, survey data, and U.S. Department of Education school data to expand upon information provided in the interviews.

Outcome 1: Increased participation and professional growth of educators in science.

The D109 team was formed in 2004 with five members: a school administrator, two fourth grade teachers, one fifth grade teacher, and one fourth grade gifted teacher. Table 2 lists the academic needs the team identified when joining the NES project in 2004. During its NES participation D109 developed strategic and implementation plans that showed how it would address these academic priorities through the NES project. The NES team and its students have participated in numerous NASA activities, including DLN events, trips and presentations at the field center, reduced gravity flight, and RGO balloon flight. Tables 3 and 4 summarizes the professional development opportunities and NASA resources that D109 has taken advantage of as a NASA Explorer School.

The next section examined the extent to which the D109 school implementation of NES addresses the six guidelines for professional growth and development described below.

Guideline 1 Instructional Strategies.

During its partnership with NASA, D109 has participated in a number of NASA professional development opportunities, and teachers report that they have used a lot of NASA-related resources for teaching. Here are some science activities in which the D109 team incorporated NASA-related materials:

- The teachers of D109 observed the students who participated in the Reduced Gravity Flight program and found out that the students had fun exploring and using the hands-on materials. A team member described it as "the ride of a lifetime" (Focus Group Interview, May 25, 2006).
- The resources from NES excite teachers to teach science. "Having the rocket take off over the Atlantic was a high of my life. Thousands of people talked to the kids about their rockets and were so impressed" (Focus Group Interview, May 25, 2006).
- In 2005 NASA selected D109 teachers to implement the FreeSpace project, which offers students an opportunity to fly secondary experiments on NASA Rocket Program missions. The FreeSpace project was available to them through the NES project.

In addition to our analyses from the case study, we report some key findings from the survey data on D109. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings.

- When asked how often students in this class take part in hands-on/ laboratory activities, two teachers responded "1-3 times per month," and the other two teachers responded "1-3 times per week" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often students in this class take part in working in small groups to come up with joint solutions or an approach to a problem or task, three out of four teachers responded "1-3 times per week" in the TLC survey.
- Here is how teachers responded to questions in the TLC survey regarding how often the teachers accomplish the following goals:
    - Elicit students' ideas and opinions: Three out of four teachers responded "always."
    - Get students to justify and explain their reasoning: Two teachers responded "very often," one said "often," and another responded "always."
    - Have students relate what they are working on to their own experience: Three out of four teachers responded "very often."
- When asked in the Teacher Involvement survey how much they anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, three out of four teachers responded "quite a bit."

Guideline 2 Time Intensive.

The professional development activities at D109 were intensive and sustained. The D109 team disseminated inquiry teaching strategies to non-NES teachers at their school and helped them become familiar with the idea of inquiry as they modeled it in NASA-related programs. Here are two examples of how D109 teachers found ways to extend professional development opportunities into sustained professional growth for teachers:

- D109 teachers attended robotics teacher training and ongoing professional development using JPL LEGO® robotics experts and DLN resources from NASA. Teachers had six sessions for a total of 20 hours. [1] "The professional development, training, and conferences have been phenomenal" (Focus Group Interview, May 25, 2006).
- The D109 team presented at the National Science Teachers Association conference. Team members shared things they learned from participating in NES. In 2006 the team presented "Flying Ants—A Free Space Adventure" about an inquiry-based curriculum that helped students explore how ants could survive a trip into space in the nosecone of a rocket.

Guideline 3 Classroom Practices.
As participants in the NES project, D109 teachers are able to bring real-world, firsthand, scientific practices to the classroom. D109 teachers have been working with about 25 students from the fourth and fifth grades on an experiment that will help the students understand the effects of microgravity on soap bubbles. For almost two years the students have been learning about mathematics, science, and engineering while conducting their experiment. [2]

In addition to our observation from teacher focus group interviews, we also sought out some key findings from the Teacher Needs and Involvement survey on how much NES D109 teachers anticipate the following in their instruction:

- Align NASA STEM-G resources to national, state, or district standards: All four teachers responded "some."
- Integrate more space science into my instruction: One teacher responded "a lot"; two, "quite a bit"; and one, "some."
- Integrate more technology into my instruction: Three teachers responded "some," and one responded "a little."
- Integrate more geography into my instruction: One teacher responded "quite a bit"; two, "some"; and one, "a little."

[1] Source from NASA Explorer School website:
http://aesp.nasa.okstate.edu/efolio/index.php

[2] Sources retrieved March 27, 2007, from http://www.nasa.gov/news/

- Incorporate more technology into my instruction: All four teachers responded "some."
- Integrate more engineering into my instruction: Three teachers responded "some," and one responded "a little."
- Incorporate more STEM-G career information into my instruction: Three teachers responded "some," and one responded "quite a bit."

Guideline 4 Content Knowledge.
As identified in the D109 strategic plan, the NES project helped D109 NES team and non-team teachers develop their content knowledge and increase their use of NASA resources. The aerospace education specialists were instrumental in suggesting curriculum-specific resources, helping with kickoff and family events, and providing on-site professional development.

Teachers attended content workshops and shared what they learned with their colleagues and planned how they would integrate the knowledge into the curriculum. As NES team members became more familiar with NASA resources, they made specific suggestions to other teachers for what could be integrated into the curriculum. "The students want to know how bubbles react in a reduced gravity environment, specifically the duration of a soap bubble, its size, and direction of travel in reduced gravity," said [principal at D109]. He said the teachers flying on the aircraft expect the new environment would produce different results compared with experiments on the ground.

In addition to our observations from teacher focus group interviews and the NES e-Folio website, we also sought out some key findings from the Teacher Needs and Involvement survey on teachers' comfort with teaching concepts in each of the following areas:

- Science: Two teachers responded that they had "a lot" of comfort teaching science concepts now, while two others said they had "quite a bit" of comfort.
- Educational technology: Two teachers responded "quite a bit" of comfort, and two others reported "some" comfort in teaching educational technology concepts now.
- Engineering/Technology education/Robotics: Two teachers reported "some" comfort, and two others "a little" comfort in teaching engineering concepts now.
- Mathematics: Two teachers reported "a lot" of comfort, another said "quite a bit," and another "some" comfort in teaching mathematics concepts right now.
- Geography: Two teachers reported "a lot" of comfort, and two others had "quite a bit" of comfortable in teaching geography concepts right now.

Guideline 5 Active Learning.
The regional field center offered STEM-G curriculum and activities that were aligned with California state standards, and this eased the teachers' workload when it came to the implementation. As one field center staffer described it, "We did not tailor it to needs, we tailored it to what we had to offer and what we thought people wanted just from our experience with AESP in the field. That was not a bad thing because we couldn't tailor it to 25 different teachers' needs. Now we have five sets of needs. It is a lot more targeted. We used to align everything with national standards. Now with being at the same field center and all we have are schools from Southern California, we can stick with state standards, which makes it a whole lot more meaningful for the school" (Field Center Coordinator Interview, 2005).

The D109 team reported that teamwork and the principal's support are the keys to successful implementation. The team is excited about the project, and members are enthusiastic about the impact of the project on themselves personally and their students. Here are some of the teamwork strategies that D109 applied to its NES implementation activities.

- The team divides the tasks so that each subject has its own liaison. The team lead said, "One person does technology, one does supply ordering, one does math and science, one does publicity, and then we all pitch in to help get the job done. We have a close team" (Focus Group Interview, May 25, 2006).
- Another D109 team member expressed that "our team was intact, even before the start of the project. We know each other well, and this has helped us be successful" (Focus Group Interview, May 25, 2006).
- "Without our principal's support, we could not be successful, and we have a great principal. You have to be a committed team. You have to commit to at least three years of this. NASA should know that teamwork is essential. They should be aware and recommend it" (Focus Group Interview, May 25, 2006).

Guideline 6 Coherence.
The D109 reform strategies are connected to the following aspects of school reform in STEM-G areas within the team and schoolwide that promote teacher professional growth, curriculum improvement, and leveraging NES funding to pursue additional partnerships and funding. Here are descriptions of these strategies fostering coherence:

- D109 received the Educator Grant from the Air Force Association (AFA) in 2007. The Educator Grant is designed to promote aerospace education activities in kindergarten through 12th grade classrooms. The program encourages development of innovative aerospace activities within the

prescribed curriculum. The Educator Grant program also strives to help establish active relationships between the local AFA chapters and their local school systems.

- The D109 team has taken its experiments out of the classroom and into NASA's "Weightless Wonder," a flying microgravity laboratory at NASA's aircraft facility at Johnson Space Center in Houston. Team members prepared themselves and their experiments for a unique experience outside the bounds of gravity aboard the modified C-9 aircraft. The C-9 produces 25 seconds of weightlessness by flying in a rollercoaster-like path of steep climbs and freefalls.
- One of the goals of NES was to incorporate as much as science and math as possible into the classrooms, even in the after school programs. "We want to get kids excited about going to school and about science and math in the fourth and fifth grades, or they will not do it later" (Focus Group Interview, May 25, 2005).

The evaluation team reviewed survey questions from the Team Lead survey and found that the D109 NES lead teacher perceives the team as "very satisfied" with its experiences as a NASA Explorer School. In response to more specific questions, the team lead reported that the team is very satisfied with NASA staff assistance in helping it in each of these areas: the implementation plan, involvement of administrator team member, family involvement, NASA staff assistance for integration of NASA materials and modeling inquiry, and for their communications and referral services. The team lead cited increased amount of family involvement, the amount of science being taught, and the amount of interaction the students have had with JPL engineers, astronauts, and other NASA personnel as the greatest benefits for their school. Over the past year the team has requested assistance from its NASA field center staff on a weekly basis via telephone or e-mail and has sought monthly assistance via DLN.

Here are some of the challenges the D109 team leaders expressed:

- Need more in-school time to plan and prepare for NES activities.
- Adapting to the delay in the RGO flight meant that science clubs were not implemented as planned—RGO experiments were extended, but other activities had to be eliminated.
- Involving the whole school has been difficult, but the team lead reported that 29 teachers at the school are using NASA materials.

Summary of How D109 Meets Outcome 1.
Overall, the D109 team was positive about the NES project. The team was excited about what they learned through the professional development, and support within the team has been phenomenal. "No one says 'That is not my job.' We work together. And this is the most hyperactive group of women I've ever met"

(May 25, 2006). The D109 team has met each guideline outlined as indicators for a successful implementation. Teachers use NASA materials to promote STEM-G learning through the use of more inquiry strategies and the technology tools that are available to them. The supports from AES and field center staff have made the process of implementation work more smoothly. They deliver the content knowledge in the professional development workshops and model the inquiry at the school where they interact with teachers, students and parents.

Outcome 2. Increased assistance for and technology use by educators in schools with high populations of underserved students.

The D109 team purchased the following technologies with NES funding:

- TV DVD
- Robotics
- Rockets
- Videoconferencing equipment

The partnership with NES allows D109 to receive academic assistance for technology and encourages technology use by educators in school. With the purchase of robotics materials, staff members and parents attended LEGO robotics training sessions, and teachers provided facilitation for student experimentation during robotics after-school club meetings. Through the use of DLN programs, Robotics Teacher Training, and rocket activities, D109 has made use of purchased technologies.

DLN was used to support student research on microgravity through teacher participation in the Reduced Gravity Flight Opportunities. Fourth and fifth grade students used DLN to formulate questions related to radio telescope missions and present them to a NASA scientist.

Outcome 3. Increased family involvement in children's learning.

D109 initiated several family involvement activities since it joined the NES program in 2004. Teachers have enjoyed successful interaction with parents during family astronomy night, space night simulation, family rocket night, and family science night. These activities were designed to increase parents' awareness of school events and their children's learning, with as many as 400 parents attending. In addition to NASA-related activities and events, the team has extended the family and community involvement to non-NASA related activities.

"We had a family science night, We had a family astronomy night. Our parents have been extremely involved. Four hundred parents showed up to our family nights" (Focus Group Interview, May 25, 2006).

"With family night we have a sign-in sheet. Family night has increased the smiles on faces, and the enthusiasm shows the impact. Now that parents have participated, we can't stop it. The activities will keep going on now. Kids give mini-lessons to parents now, and this is great! When we had Stars Astronomy Night for parents and kids, there were so many people looking through eight telescopes. They obviously don't want this kind of thing to stop" (Focus Group Interview, May 25, 2006).

In the NASA Explorer School e-folio, the D109 team has projected several family events including:

- Space Night Simulation: Culminating activity to space and astronomy unit. 1st and 4th grade students do an overnight space simulation with a simulated launch and space science activities. Over 100 students participate with 70 parents doing activities and 50 parents spending the night.
- Family Rocket Night: Families design and build their Estes model rocket and submit them for competition in various categories.
- Family Rocket Workshop: Families learn safety procedures and how to build Estes rockets.
- Family Science Night: JPL personnel with rover, Edison demonstration of electrical principles. Families will have a choice of science activities presented by teaching staff and outside agencies. NASA personnel will make presentations of robotic and infrared technologies.

"D109 is an exciting elementary school where our community experiences family-oriented science activities. To start the year, we have a Family Science Night, which includes hands-on science activities presented by each grade level. This year our main attraction was a demonstration by an astrophysicist from NASA/JPL who amazed our 400 people with demonstrations of infrared technology. In addition to our 135 families, our district superintendent and assistant superintendent of instruction were in attendance. The next major family event will be our Family Astronomy Night. Families will view the heavens with telescopes, assist their children to create a planetarium filled with student-designed constellations, and learn about our latest discoveries in the outer regions of space. In the spring our families will participate in Family Rocket workshops to learn about model rocketry, and then on Family Rocket Night, families will launch their rockets under the stars. All of D109's students will have the opportunity to launch a variety of

> rockets during Rocket Week in the spring. A family activity that is new to D109 this year is our Robotics Club, which meets after school to work on the PROBE challenge. Parents help to set up and organize our materials as eight teams of fifth-graders work to program their team's LEGO tankbot. These students will become trainers for younger students as the year progresses. It is obvious that D109 NES is a busy place with excited and motivated students and families."[3]

Searching for postings about D109 outreach and family events on the web, we found the following comments from parents of D109 students. D109 parents are positive about the school principal, staff, and teachers and delighted to see that the school test scores are good. The parents express that the hands-on experience with computers helps their children to learn better.

> "A wonderful school! The #1 principal, and staff are caring and dedicated. I currently have an honor roll 4th grader attending. My older son attended 3-5th and was very prepared for middle school. Accept no substitute! [D109] is the best, and it has the test scores to prove it" (January 2007)!
>
> "We have 2 children that attend [D109] and are very happy with the staff, teachers, and especially our new principal" (April 2005).
>
> "My children have been attending since Kindergarten. The [D109] school has excellent parent involvement. The teachers really care about the student and their advancement in academics" (March 2005).
>
> "This has been a wonderful school for my son. It has been challenging with a lot of hands-on experience on computers and a lot with space. A lot of parent involvement is needed. It is rewarding being able to participate so much with my child's education" (January 2005).
>
> "Great school, good kids, excellent teachers, and lots of parent participation" (July 2004).
>
> "Overall I would say that [D019] is a great school. My daughter has been there for 4 years, and we really have not had any problems. Her teachers have been awesome. … The only thing I would have to say is that the office staff seems to be unorganized, anytime I would ask a question to the office, no one ever seemed to know the answer. Overall, though, we have been pleased with

[3] *Source: NASA Explorer Schools efolio. (2006). Retrieved March 14, 2007 from http://aesp.nasa.okstate.edu/efolio

[D019]. And as far as safety goes, I have never been too keen on letting little girls go off to the restroom by themselves. You never know who could be hiding in those bathrooms, so that makes me nervous. But they seem to be overall pretty safe; it even seems that the janitor is keeping an eye out" (May 2004).

"My daughter has attended [D109] since Kindergarten, and I have to say that she has had the most wonderful experience. All of her teachers have taken the time to answer any questions or concerns we have had throughout the year. I am so glad that she was able to build such a strong educational foundation which, I am certain, will remain throughout her school career. She will be leaving this year moving on to junior high, with the help of all her teachers, she is able to take that next step! Thank you to all the staff. You have been wonderful throughout the years" (May 2004)!

"As a teacher … and a parent of a child at (D109), I would have to say that not only is [D109] the best school in [the area], but it is one of the top 3 in the entire county" (February 2004).

"I would like to say I am just disgusted with how things are handled there at this school. I needed to get in touch with the principal and couldn't. I was very upset when I didn't get the help I wanted and or the help my son really needed" (February 2004).

"I recently transferred my two children to [D019]. I was concerned that the staff and students would not be as accepting of a mid-year transfer, but, everyone has been so kind and helpful and generous with their assistance, I couldn't imagine a better transition. I am extremely excited about the level of higher learning here. So far, [D019] is exceeding expectations in every aspect" (September 2003)!

"I have been a proud and lucky [D019] Parent for 7 years now. My daughter just left, and my son has another 3 years there. This is an awesome school with a terrific PTA and Booster Club. The teachers are dedicated and hard working, as is the office staff. After hearing other parents' horror stories of their schools, I am privileged to have my children at [D019]" (August 2003).

"[D019] is a great school! The staff is friendly, the teachers actually care about your child's education, and the principal is hands on and controls his school…. If you can get your child into this magnet school you won't have any regrets" (June 2003)!

Outcome 4. Increased student interest and participation in STEM-G.

Teachers observed a change in students' attitudes regarding their familiarity with STEM-G related topics. NASA activities such as AstroCamp, Science of Energy Fair, S'Cool, and the Robotics Club have all had an impact on student interest and participation. The following strands are indicators of what it means for students to have interest and to participate in STEM activities. Examples from teachers' observations are provided after each strand.

Participate productively in STEM practices and discourse.

> "Students learn how to safely collect images of the sun using a sunspotter telescope to compare and contrast what is published daily on spaceweather.com" (Focus Group Interview, May 25, 2006).

As input in NASA e-Folio website, students are encouraged to participate in numerous NASA-related hands-on activities. For example:

- AstroCamp was an activity in which students spent three days in the mountains of Southern California immersed in hands-on activities.
- S'Cool was an activity where students observe the sky, record observations, and enter data into the NASA/LARC database via the Internet.
- A DLN event was designed where fourth and fifth grade students could formulate questions related to radiotelescope missions and present them to a NASA scientist through DLN.
- Goldstone Apple Valley Radiotelescope Mission was an activity where student teams connected with mission control in Apple Valley via Internet, remotely operated the 34-meter radiotelescope, and initiated data collection.

Noticeable curiosity in STEM-G topics and events.
A teacher commented on a noticeable change in the students' attitude toward events in the NES program:

> "Kids have just become jaded about their experiences. They take for granted that astronauts come to lunch and that an astrophysicist talks to them. Kids go on to middle school and complain about no science. They want science like they had in elementary school" (Focus Group Interview, May 25, 2006).

Change attitudes about learning.
A teacher explained the type of change the students at D109 exhibited:

> "I don't see any systematic change coming out of NES, but I see real change of attitudes in the kids" (Focus Group Interview, May 25, 2006).

Actively participate in hands-on and authentic scientific research.

> "Thirty-two [D109] pupils gave up an hour of after-school time one day a week to learn how to build and program their rovers. Twenty of the pupils went to JPL. The other 12 stayed behind to give a robotics demonstration to other pupils at the school. Some of the pupils watched the competition broadcast on the JPL website"[4]

> "Students learn how to safely collect images of the sun using a sunspotter telescope to compare and contrast what is published daily on Spaceweather.com" (e-folio).

Outcome 5. Increased student knowledge about careers in STEM-G.

Through the sharing of information with peers, demonstration of scientific knowledge in numerous activities, and changing attitudes, students at D109 have demonstrated an increased awareness of careers and topics relating to STEM-G. The following strands indicate students' knowledge about careers in STEM-G. Students who exhibit knowledge about careers in STEM-G demonstrate:

Change in self-identity.
D109 teachers perceived that the presence of astronauts had some impact on what students believe they can do in the future.

> "…we have three different astronauts at the school" (Focus Group Interview, May 25, 2006).

Increase understanding of and enthusiasm about STEM-G careers.

Having astronauts and speakers visit the school had positive impact on increasing students' understanding of STEM-G related careers. A teacher explained some of the activities D109 students have been involved with and their reactions to different activities:

> "We have taken two kids to Washington, and we have taken two kids to Virginia. Space excites the kids. We want to get kids interested. Teachers have more experience with science so we can do it" (May 25, 2006).

[4] Source Retrieved March 27, 2007, from http://www.pe.com/localnews/fontana/stories/PE_News_Local_S_jpl23.1e5515e.html

> "We were celebrating a space night and NASA coordinators set up a conference with a person who was at the Mission Control center during Apollo 13" (Focus Group Interview, May 25, 2006).

As input in the NASA e-Folio website, teachers have incorporated activities that also have increased student knowledge about careers in STEM-G, such as sunspotters and DLN events.

Share information with their peers and parents.
With the Robotics Club, students were trained and then assisted younger students in the introduction of robotics. Also, students shared their programming successes with members of the community, including the school board. The Student Symposium was designed as a project to answer scientific challenges which would be shared with the community and NES affiliates. Family Rocket Night enabled the students to share the information they had learned about STEM-G careers with their families and parents.

Outcome 6. Increased student ability to apply STEM-G concepts and skills in meaningful ways.

Specific examples of how students increased their ability to apply STEM-G concepts and skills were seen in their participation in DLN events and sunspotter telescope activities.

Understand and use scientific explanations of the natural world in context of a problem-solving activity.
DLN events gave the students opportunities to understand and use scientific explanation in context of a problem-solving activity.

Understand how to use and interpret the data obtained from technology tools to support STEM-G inquiry activities.
Sunspotter telescope activities increased the students' abilities to apply STEM-G concepts and skills in meaningful ways.

Demonstrate increased student performance in STEM-G and related subjects like language arts.
In searching for D109 student achievement in reading and mathematics, we found that the results from California Standards Tests and Norm References Tests show that students at D109 are performing above state standards. California Standards Tests are administered only to students in California public schools. These tests determine student achievement of the California Academic Content Standards and provide feedback on their success given what they are expected to know in each grade level and subject. The D109 state report card

shows that this school has met its annual yearly progress goals from 2003 through 2006.

In 2005 California Standards Tests results show the percentage of students that scored at proficient (meets standards) or advanced levels (exceeds state standards) in English language arts was 53percent, mathematics was 62 percent, and science was 47 percent—well above both district and state California Standards Tests averages. From 2003 to 2005, D109 students showed significant gains in mathematics and science. Tables 5 and 6 display students' achievement scores in math and English/language arts. Both tables show improvement from far below basic/below basic categories to basic/proficient and advanced categories.

Table 1. School Demographics

	2002-2003	2003-2004	2004-2005	2005-2006
Student Population	803*	838*	836*	
Black, non-Hispanic	171*	202*	203*	
Asian	79*	83*	68*	
Hispanic	210*	220*	232*	
American Indian, Alaskan Native	6*	7*	7*	
White, non-Hispanic	325*	318*	315*	
School Location (rural, suburban, urban, large central city)	Urban fringe of large city*	Urban fringe of large city*	Urban fringe of large city*	
School Type (public, private, charter, magnet)	Magnet*	Magnet*	Magnet*	
Title 1 status (yes or no)	No*	No*	No*	
English Language Learners				
Free and Reduced Price Lunch	27%*	34%*	34%*	
Teacher Population	36*	37*	37*	

Note: Grayed-out cells indicate that data is not available as of March 14, 2007.
Source: Common Core of Data (CCD), "Public Elementary/Secondary School Universe Survey" , 2002-03 v.1a, 2003-04 v.1a, 2004-05 (Preliminary) v.0f-preliminary. National Center for Education Statistics (NCES). Retrieved March 14, 2007, from http://nces.ed.gov/

Table 2. Summary of Academic Needs Identified by D109 in 2004*

Priority	Discipline	Category	National Standard
1	National Science Education Standards	Physical Science	Transfer of Energy
2	Standards for Technological Literacy	The Nature of Technology	Students will develop an understanding of the characteristics and scope of technology
3	Principles and Standards for School Mathematics	Data Analysis and Probability	Develop and evaluate inferences and predictions that are based on data
4	Principles and Standards for School Mathematics	Data Analysis and Probability	Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
5	Principles and Standards for School Mathematics	Algebra	Analyze change in various contexts
6	Principles and Standards for School Mathematics	Number and Operations	Compute fluently and make reasonable estimates
7	National Science Education Standards	Life Science	Structure and function in living systems
8	National Science Education Standards	Physical Science	Motions and Forces
9	National Science Education Standards	Earth and Space Science	Structure of the Earth system
10	Standards for Technological Literacy	Technology and Society	Students will develop an understanding of the influence of technology on history

Source: D109 Needs Assessment. (2004).

Table 3 NASA Professional Development Opportunities That D109 Teachers Completed

National Science Teachers Association (NSTA)* ***
Faculty presentations at NSTA*
Professional development training*
Conferences/Workshops paid by NASA***
NES Summer Orientation workshop***
JPL visit***

* Source: 2006 Spring Team Interview
** Source: Spring 2006 Team Lead Survey
*** Source: Fall 2005 Team Lead Survey

Table 4 NASA (and NASA-affiliated) Resources Used

DLN events* **
Astronaut visits* **
Student trips and presentations at the field center*
NASA speakers (engineers, astronauts, and other NASA personnel)* **
Reduced gravity experiment*
RGO Balloon Flight** ***

* Source: 2006 Spring Team Interview
** Source: Spring 2006 Team Lead Survey
*** Source: Fall 2005 Team Lead Survey

Table 5. NES D109 Math Achievement Scores

Year	Grade	Far Below Basic	Below Basic	Basic	Proficient	Advanced
2003	2	10	12	14	31	34
2003	3	5	14	19	31	31
2003	4	2	12	26	33	27
2003	5	16	18	21	31	15
2004	2	2	12	24	35	27
2004	3	6	14	23	30	27
2004	4	2	18	29	29	22
2004	5	13	21	23	28	15
2005	2	4	7	14	28	46
2005	3	6	13	19	30	31
2005	4	7	16	22	26	30
2005	5	12	8	24	26	29
2006	2	0	4	11	41	44
2006	3	7	10	15	32	36
2006	4	3	14	27	24	32
2006	5	12	15	14	33	25

Source: California Department of Education. (2007). Retrieved March 14, 2007, from http://www.cde.ca.gov/

Table 6. NES D109 English/Language Arts Achievement Scores

Year	Grade	Far Below Basic	Below Basic	Basic	Proficient	Advanced
2003	2	14	20	33	24	10
2003	3	11	13	29	29	18
2003	4	4	6	28	41	22
2003	5	8	11	35	38	8
2004	2	5	21	33	30	11
2004	3	11	19	30	30	9
2004	4	5	11	33	29	22
2004	5	14	9	24	34	19
2005	2	6	10	28	32	24
2005	3	10	15	31	29	14
2005	4	7	11	26	34	22
2005	5	8	6	27	28	30
2006	2	3	6	24	42	25
2006	3	9	8	29	35	19
2006	4	7	6	30	23	34
2006	5	9	8	26	33	23

Source: California Department of Education. (2007). Retrieved March 14, 2007 from http://www.cde.ca.gov/

NASA Explorer Schools Case Study Profile: E98
2004 Cohort–Rural Mississippi Public Middle School: Grades 6-8

Summary Comments Regarding E98
E98 is a grade 6-8 public, rural, middle school and is one of three schools in the school district. E98 serves a high minority, low-income population of students. Low income and below poverty level families comprise 42% of the student population. The population of the two counties that supported by this public middle school is 8,643. The combined per capita income for these two counties is $21,917. Of the approximately 350 students, 98% are African American, 3% are Caucasian, and 0.67% are Hispanic. The percentage of students who participate in free/reduced lunch is 100%. More details about the school's demographics are provided in Table 1.

Here is a description of other characteristics of E98 and the community it serves written by the school NES team:

> For the past several years, the Mississippi Curriculum Test mathematics scores for E98 students have been well below the state average. While the most recent scores show an improvement, E98 School students continue to have a serious deficiency in the area of mathematics. It is our goal to improve our students' performance on all areas of the MCT. Another area of concern is our students' lack of preparedness for [advanced] level science and mathematics courses taught at the high school level. It is our goal to provide our students with the prerequisite skills they need to be successful in those courses.
>
> Our final concern is the need to make students aware of and prepared for math/science/technology related careers. In the year 2000, 65% of jobs required workers who were highly skilled and that number is increasing exponentially. Currently few of our students consider careers in math or science other than nursing or other medical related fields. It is our goal to prepare our students for careers in math/science/technology.
> With the help and support of the NASA Explorer Schools program, we hope to bring about positive changes for the students of E98 and [its surrounding] community.

The E98 needs assessment recognizes that for the past several years, the Mississippi Curriculum Test mathematics scores for E98 students have been well below the state average. This is reflected in Table 2, in which E98 identifies their

top five needs as math-related. Table 2 also reflects E98's concern that students are made aware of and prepared for math/science/technology related careers by listing technology-related needs as items six through eight.

Here are some of the successes that E98 achieved during its three-year period as a NASA Explorer School. The team reports that "The financial part of [the NES project] has been fine, [and the NES coordinator and AES representative] have been very supportive…" (Focus Group Interview, May 9, 2006).

- E98 students responded to the Return to Flight exhibits with increased awareness and enthusiasm about science, and space-related careers with NASA.
- E98 teachers observed their students' demeanor while taking the math section of the state standardized test and found that they were more confident than in the past years. They felt the students were better prepared this year and have higher hopes that they will see an improvement in the math scores.
- The teachers' expectations were fulfilled in regard to improving their test scores. The MCT scores from the Mississippi Department of Education showed that E98 students at all grade levels have improved across all content areas since 2003. Particularly, the 8th grade math score increased from 23% to 40%, 7th grade math score increased from 12% to 19%, and 6th grade math score increased from 18% to 47%.

Two challenges that emerge from the E98 case study analysis of this school's implementation of the NES project relate to time and communications.

- E98 identified time as the major challenge they faced in implementing the NASA Explorer Schools program.
- The E98 field center coordinator listed communication with the E98 team as being difficult due to lack of response from the E98 team.

We examined schoolwide achievements at E98 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcript of a focus group interview conducted by telephone with the E98 NES team. The interview was conducted May 9, 2006. We have also used school web site, survey data, NES e-Folio, and U.S. Department of Education school data to expand upon information provided in the interviews.

Outcome 1: Increase participation and professional growth of educators in science.

Two years into the NES program, the E98 team consists of the team lead who teaches four classes of sixth grade science as well as serving as the school technology facilitator, an administrator, an eighth grade science teacher, a sixth grade math and science teacher, and an eighth grade math teacher. The team remained the same through the second year, but will change in 2006-2007 when one team member is scheduled to retire.

The E98 teachers and students have participated in numerous NASA activities, including NASA Explorer School orientation and content workshops as well as regional and national conferences. Their selection of conferences and resources are aligned with their needs assessments and show an emphasis on mathematics and technology. Tables 3 and 4 provide a summary of the professional development opportunities and NASA resources that E98 has taken advantage of as a NASA Explorer School. Opportunities were shared beyond the NES E98 team with non-team teachers. In addition, on-site professional development opportunities were made available to teachers from all three schools in their district, thus providing a much wider dissemination of resources and professional development throughout a low income, high diversity region.

The next section examined the extent to which the E98 school implementation of NES addresses the six guidelines for professional growth and development described below.

Guideline 1. Instructional Strategies.
Through participation in the GLOBE program that was introduced at the first NES orientation workshop, students have been involved in the process of collecting and analyzing data. Students learned about weather measurement processes and tools and how to use technology to assess water quality.

- A caption on one of the photos of student lab activities provided in the NES digital portfolio shows how students used a digital pH meter to check water quality as part of their Globe data investigations.
- "Inquiry-based learning, several of them [teachers] have used the techniques that were taught in our professional development [at Field Center E] in their own classrooms. So, it has definitely helped." (Focus Group Interview, May 9, 2006).

In addition to our analyses from of qualitative data, we report some key findings from the survey data on E98. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings.

- When asked how often do students in this class take part in doing hands-on/laboratory activities, two teachers responded "sometimes," one responded "1-3 times per month, and one responded "1-3 times per week" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often do students in this class take part in working in small groups to come up with joint solutions or approach to a problem or task, three out of four teachers responded "1-3 times per month" in the TLC survey, and one responded "almost everyday."
- Here is how teachers responded to questions in the TLC survey regarding how often E98 teachers accomplish the following goals:
    - Elicit students' ideas and opinions: three out of four teachers responded "very often," and one responded "sometimes."
    - Get students to justify and explain their reasoning: two teachers responded "often" and two responded "always."
    - Have students relate what they are working on to their own experience: Two teachers responded "often," one responded "very often," and one responded "always."
- When asked in the Teacher Involvement survey how much they anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, two teachers responded "some," and two responded "quite a bit."

Guideline 2. Time Intensive.

The E98 team has organized schoolwide professional development activities and has invited other, non-NES teachers to attend these events. The E98 team members describe how their strategies for integrating NES activities schoolwide.

- "We involve as many faculty members schoolwide and district-wide as possible anytime we have one of the staff developments where field representatives come in and do the staff developments with us. We make sure that others, that everybody is involved as they possible can be so that everybody's exposed to that training and can, and can get the free materials and all. And then we, anytime anything comes in the mail that we, we always get packages for core materials and bulletin board ideas and, and just everything. And we make sure that all of that gets shared with other teachers in the school so that other people have a chance to use the NASA materials, and help implement the program too." (Focus Group Interview, May 9, 2006).

- E98's team lead has found that it has been "somewhat easy [to encourage faculty members to attend special opportunities and professional development]. It's easy to encourage them. It's not always easy to get them to attend. But we do have several, a number of teachers who are very, very excited and will even ask when are we having another NASA professional development? So, basically that's been easy. We just, like I said, it's easy to, to encourage them, it's, it's not always easy to get everyone to be there." (Focus Group Interview, May 9, 2006).

Guideline 3. Classroom Practices.
The E98 team has frequently called upon their education specialist to assist them in identifying NASA materials for their curriculum.

- "Anytime [the E98 NES team] need[s] suggestions for materials to use, all we have to do is email or call, and [the field center staff] glad to help us, send us suggestion of things to do." (Focus Group Interview, May 9, 2006).

Guideline 4. Content Knowledge.
The E98 team has organized professional development workshops for its school and for regional schools as well as taken advantage of NES support to attend NASA content and STEM-related education national conferences.

- "One thing that has helped me personally is all of the professional development opportunities other than just those involving my field representatives coming to my school. I had opportunities to attend national conferences like the, National Educational Computer Conference in Philadelphia last, excuse me, last summer. And the National Middle School Conference, which was also in Philadelphia, this fall. And several other wonderful workshops and things that I've been able to go to. I'm, Technology Immersion Workshop that I went to at the [Field Center J] last summer really gave me a lot, I mean, it was wonderful training. It gave me a lot of professional development and really helped me grow in my technology skills…I've learned so much from all of those opportunities that I've had. And on another little note, it also broadened my horizons in another way because it was the first, I got, I got to travel to parts of the country that I've never, have never been to before and probably never would have had the opportunity to go to if it had not been for the Explorer Schools program. Other teachers have taken part in these opportunities as well." (Focus Group Interview, May 9, 2006).

- In January 2007, E98 hosted a professional development session entitled NASA and Science Fairs with teachers from the three schools of E98 School District.
- In February 2007, E98 hosted a professional development session on robotics for teachers from the three schools of E98 School District. This activity addressed the following needs defined by the school:
    - Recognize and apply mathematics in contexts outside of mathematics.
    - Use visualization, spatial reasoning, and geometric modeling to solve problems.
    - Apply and adapt a variety of appropriate strategies to solve problems.
    - Understand measurable attributes of objects and the units, systems, and processes of measurement.
    - Organization and consolidate their mathematical thinking through communication.
    - Students will develop an understanding of the attributes of design.
    - Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
    - Science as a human endeavor.
- In March 2007, an E98 8th grade science teacher began weekly sessions of the E98 Robotics Club. A projected 20 students are expected to receive instruction in the construction and programming of robots.

Guideline 5 Active Learning.
The E98 team tries to meet regularly, usually once a week to share updates on what each teacher is doing and upcoming opportunities.

- "We [the teachers] try to have meetings, a lot of us fortunately; most of us on the team have the same planning period. So we usually talk and, and it's usually not formal. It's usually just...informal, but we kind of discuss NASA team things, probably at least once a week we'll discuss what, you know, what everybody's doing, who's using what instructional materials and, you know, let's share this with somebody and what, what staff development thing do we need to try to talk about to get for the next time and that. So, you know, it's just more of an informal." (May 9, 2006).

Guideline 6 Coherence.
Eighth grade students at E98 were trained in a NASA activity called Journey to Mars and prepped to present this activity to elementary students at the feeder

school to E98. The older students were guided to learn attributes of design from this training and mentoring activity. The teachers chose this activity from their introduction to it at the first NES orientation.

Teacher relationships with the NASA coordinator and education specialist have been good according to teacher responses in the team interview.

- According to the team lead, "They have provided us with wonderful staff development. Yes, they, they come to our, we have a representative who comes to our school and does staff development for us here based on what we need. We're provided with a list of available workshops and we get to choose the ones that we need that fit our plan. Or that fit our needs. And, for the, for the particular school year. And they make sure, you know, that he's right here. He usually comes in and spends the day and goes over other things and is really interested in what's going on in the school and takes time to talk with us and help us work out any, any problems that he can help us with." (Focus Group Interview, May 9, 2006).
- The two new NES staff members at [Field Center E], visited E98 on October 30, 2006, to get acquainted with the NES team members. Also visiting was the former field center aerospace educator. The NES Staff toured the school and met with NES team members to plan events for the 2006-7 school year.

Summary of How E98 Meets Outcome 1.
E98 team members have successfully used inquiry-based learning that they learned from the professional development. The team has made efforts to help other faculty to buy-in NASA materials and activities. However, the faculty buy-in to NASA stuff has been slow. Field center staff has been instrumental in terms of responding to the team needs and getting things organized for the school. The professional development opportunities have helped teachers to improve their STEM-G related content knowledge as well as their technology skills.

Outcome 2. Increased assistance for and technology use by educators in schools with high populations of underserved students.

The E98 team purchased the following technologies with NES funding:

- SmartBoard and SmartBoard rolling floor
- Dropper Pipettes
- Test tube rack
- Funnel set
- Beaker tongs

- Lab tools set
- Student hot plate
- Double scale thermometer
- Gram centimeter cubes
- Trundle wheel
- Meter sticks
- Stopwatch
- A+ Science Fair Projects
- Guide to the Best Science
- Easy Science Fair Projects
- Clever catch globe
- eTrex GPS
- Middle standard GLOBE kit
- Glass beakers (150 ml, 250 ml, 400 ml, 50 ml, 600 ml) and plastic lids
- Advanced cordless coaxial microscope
- Advanced stereo microscope
- Air pump
- Dual lens magnifiers
- Glass slides
- Plastic cover slips
- Plastic depression slides
- Electronic scale
- Soda bottle rocket kit
- Digital camcorder
- Video format tripod screen
- Introductory slide set
- Lego robotics classroom pack
- Robochallenge activity pack
- Technology resource set
- Robotics educator
- C=based programming educator
- Robolab icon magnets
- Magnetic board

Technology professional development workshops helped teachers become comfortable with modern technology as well as develop technical skills that they would otherwise not have been able to easily access. As the quotes below illustrate, the E98 teachers report that they are comfortable and skilled to do professional development for the faculty.

- "Again, because of the, the professional development element of the program…I know for a fact that it's helped several of the teachers become interested in using technology more. Because a lot of our professional development has involved technology." (Focus Group Interview, May 9, 2006).
- In February 2007, E98 hosted a professional development session on robotics for teachers from the three schools of E98 School District.
- In March 2007, E98's 8th grade science teacher began weekly sessions of the E98 Robotics Club. A projected 20 students were expected to receive instruction in the construction and programming of robots.

We also incorporated some of the data from Teaching, Learning, Computing (TLC) and Teacher Need and Involvement surveys to generate more inclusive picture of how E98 teachers integrate technology. When teachers were asked how many days a year does a typical student in the class use a computer while they are teaching their class, teachers responded "11-20 times" a year. Teachers also responded only "1-5 times" for using NASA materials in their classroom in a year.

Outcome 3. Increased family involvement in children's learning.

In regard to family involvement the team lead stated that, "That's an area of weakness on our part. We have not really done as much family involvement as we had planned to and as we would have liked to. We do have several things in the planning stage now for next year." The field center coordinator also reported a lack of interest in organizing family involvement activities at E98.

In searching for endeavors that are dedicated to E98, we found three family-based activities were scheduled for 2007 as scheduled in the NES e-Folio website:

- During school, a projected three families will participate with the Globe Participation activity.
- In January 2007, an estimated 20 families participated in the NASA and Science Fairs Activity
- In March 2007, an estimated 20 families, 325 students, 120 teachers who were team members and two teachers who were not team members will participate in Family Night in which students and families participate in a variety of STEM-G related activities. The activities for the family night were either suggested by the NASA field center education specialist or selected from the NASA web site.

Outcome 4. Increased student interest and participation in STEM-G.

The E98 STEM-G curriculum includes hands-on activities and opportunities to work with "live" data. The activities are aligned with their needs in math and technology areas and are selected to better prepare the students for higher-level . The team lead, speaking for the E98 NES team, has observed that the children appeared to be more confident about their knowledge and ability to apply what they know as they took the state tests.

The following strands are indicators of what it means for students to have interest and to participate in STEM-G activities. Students who are interested and participate in STEM-G activities have the tendency to:

Participate productively in STEM-G practices and discourse

- A projected 320 students are expected to participate in a Globe Participation Activity which involves gathering data for Globe protocols.
- Twenty grade 5-8 students are projected to participate in the LEGO Mindstorm robotics club. Photos of individual and pairs of students programming robotics components is posted on the E98 digital portfolio.

Show noticeable curiosity in STEM-G related topics and events

- The researchers are unable to cite evidence of this characteristic from data available. In the 2006 spring survey, the field center coordinator working with this school reported observing a lack of family and student interest at this school. The E98 team recognized these problems in the 2005/2006 school year and reported that they wanted to address these issues in the 2006/2007 school year.

Change in attitudes about learning

- Teachers report that students seem to be more confident as they take their spring 2006 achievement tests (May 9, 2006). When we looked for supporting information from the teacher and student surveys, the E98 students did not complete the student interest survey, and only one teacher completed the teacher involvement survey. Responses from this one teacher show that they believe the NES program is inspiring to both participating teachers and students. However, it is difficult to draw any conclusions from this single data point.

Active participation in hands-on and authentic scientific research

- According to the team lead, "We've had the programs in, like the Return to Flight exhibit and support that came in last year and the students got a chance to participate in a lot of hands-on activities that were part of that program. Just, you know, within the classrooms, using this, the NASA materials to kind of give the students more opportunities that way." (Focus Group Interview, May 9, 2006).
- The E98 teachers projected 320 students would be involved in the Globe Participation Activity. Students gather data for Globe protocols in this activity. Some photos of students assessing the pH of water and another liquid are shown on the school's digital portfolio for this activity.

Outcome 5. Increased student knowledge about careers in STEM-G.
The team lead indicated that increasing student knowledge about careers in STEM-G appears to be an area of improvement for E98. The needs assessment (see Table 2) included three needs aligned with making students aware of and prepared for math/science/technology related careers. This is based on E98's research finding that the number of math/science/technology jobs is expected to increase exponentially. E98 is committed to preparing their students, of whom few consider math or science careers, to be have the skills and knowledge necessary to pursue these types of careers.

The following strands indicate students' knowledge about careers in STEM-G. Students who demonstrate knowledge about careers in STEM-G also demonstrate:

Changes in self-identity
Teachers report that student confidence in math improves as illustrated in the following statement,

- "We had our state tests last week and just from observing the children's demeanor as they were taking it, the math part of the test, we feel..[hopeful] that maybe [student] scores [will] be a little bit better. They seem to be a little more confident and showed that, that they were a little bit better prepared than they had been in the past. So we, we've got real high hopes that our scores are going to be better this time." (Focus Group Interview, May 9, 2006).

Increase understanding of and enthusiastic about STEM-G careers

- The team lead stated that, "We feel like we have made some progress in making some of our students more aware of math and science careers and being excited about them through some of the speakers that we'd had to

come in and some of, the, we've had programs like the, …in flight. What was the name of that? Return to Flight." "Return to Flight exhibits that came and that really got a lot of our children fired up about the space careers, science and, careers with NASA." (Focus Group Interview, May 9, 2006).

- Mission Mathematics as well as other activities they have been exposed to through NES opportunities, "have made some improvement in the students' awareness of those careers," The E98 team lead reports (Focus Group Interview, May 9, 2006).
- The team lead reflects that being a NASA Explorer School has, "…definitely sparked some interest among some of our students in pursuing higher levels of science classes and perhaps even going into science careers. I've had several [students] who have said something to me about, well I think I want to be a scientist or I think I want to be an engineer after doing … some of the activities that we've done."
- "I would think that in any of the teachers, any of the classes where the teachers are implementing those, those materials that there's, there is gonna be an increased awareness and interest among those students in the science and math careers." (Focus Group Interview, May 9, 2006).

Share information with their peers and parents

- During school, 8th grade students will be trained on how to conduct Journey to Mars activities and present this activity to younger students as a means of introducing to 5th graders what it means to be a part of NES.

Outcome 6. Increased student ability to apply STEM-G concepts and skills in meaningful ways.

The E98 NASA Explorer Schools team introduced a variety of NASA materials and opportunities to E98 teachers to strengthen the school curriculum specifically in the areas of mathematics and technology. In 2006, the team lead indicated that E98 was hoping to see positive results on the state tests especially in mathematics. While grade 7 mathematics scores deceased from 69.2% to 63.5% proficient or advanced, grade 6 saw an increase in mathematics scores from 73.5% to 79.8 % proficient or advanced for grade 6. Grade 8 scores in mathematics jumped from 57.1% to 71.6% proficient or advanced.

Understand and use scientific explanations of the natural world in context of a problem-solving activity.

- The NASA and Science Fairs activity will address the following needs as defined by the school:
    - Apply and adapt a variety of appropriate strategies to solve problems.
    - Students will develop an understanding of the attributes of design.
    - Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
    - Science as a human endeavor.

Evidence is available to demonstrate student performance increased in STEM-G and related subjects like language arts.

- The team lead said "The major goals that we wanted to achieve were, number one, was to improve our student's math achievement. We have, for several years now, been at the very bottom of our state's math test scores, curriculum test scores. And so, one of our major goals was to do anything we could to improve that, their performance on math tests." "And we do think that, or at least we have high hopes that this year's scores. We had our state tests last week and just from observing the children's demeanor as they were taking it, the math part of the test, we feel like that there's some hope that maybe our scores are gonna be a little bit better. They seem to be a little bit more confident and showed that, that they were a little bit better prepared than they had been in the past." (Focus Group Interview, May 9, 2006).
- As science and math teachers are aligning curriculum and planning NASA activities such as those from Mission Math, Reasons for the Seasons, GLOBE or Lego Robotics as an integrated part of instruction. Teachers were provided with copies of these materials prior to curriculum planning so specific lessons can be developed to meet instructional needs based on state testing data.
- The Mississippi MCT standardized tests show gains for all three grade levels across all three content areas (Reading, Language Arts, and Math). (See Tables 5, 6, and 7).
- The E98 needs assessment recognizes that for the past several years, the Mississippi Curriculum Test mathematics scores for E98 students have been well below the state average. This is reflected in Table 2, where E98 identifies their top five needs as math-related. While the most recent scores show an improvement, E98 students continue to have a serious deficiency in the area of mathematics. E98's goal is to improve students' performance on all areas of the MCT. Based on the most recent

achievement data available, it appears that grades 5, 6, and 7 at E98 are making gains in all areas of the MCT. Refer to Tables 5, 6, and 7 for more details.

Table 1. School Demographics

	2002-2003	2003-2004	2004-2005	2005-2006
Student Population	341*	317*	349*	
Black, non-Hispanic	330*	311*	338*	
Asian	0*	0*	0*	
Hispanic	1*	2*	2*	
American Indian, Alaskan Native	0*	0*	0*	
White, non-Hispanic	10*	4*	9*	
School Location (rural, suburban, urban, large central city)	Rural*	Rural*	Rural*	
School Type (public, private, charter, magnet)	Public*	Public*	Public*	
Title 1 status (yes or no)	Yes*	Yes*	Yes*	
English Language Learners				
Free and Reduced Price Lunch	98%*	99%*	99%*	
Teacher Population	21.2*	21.3*	18*	

Note: Grayed-out cells indicate that data is not available as of March 14, 2007.
Source: Common Core of Data (CCD), "Public Elementary/Secondary School Universe Survey" , 2002-03 v.1a, 2003-04 v.1a, 2004-05 (Preliminary) v.0f-preliminary. National Center for Education Statistics (NCES). (Date not provided). Retrieved March 14, 2007, from http://nces.ed.gov/

Table 2. Summary of Academic Needs Identified by E98 in 2004

Priority	Discipline	Category	National Standard
1	Principles and Standards for School Mathematics	Connections	Recognize and apply mathematics in contexts outside of mathematics
2	Principles and Standards for School Mathematics	Geometry	Use visualization, spatial reasoning, and geometric modeling to solve problems
3	Principles and Standards for School Mathematics	Problem Solving	Apply and adapt a variety of appropriate strategies to solve problems
4	Principles and Standards for School Mathematics	Measurement	Understand measurable attributes of objects and the units, systems, and processes of measurement
5	Principles and Standards for School Mathematics	Communication	Organization and consolidate their mathematical thinking through communication
6	Standards for Technological Literacy	Design	Students will develop an understanding of the attributes of design
7	Standards for Technological Literacy	The Nature of Technology	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study
8	National Educational Technology Standards		Exhibit legal and ethical behaviors when using information and technology and discuss consequences of misuse.
9	National Geography Standards	The world in spatial terms	How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.
10	National Science Education Standards	History & Nature of Science	Science as a human endeavor.

Source: E98 Needs Assessment. (2004).

Table 3
NASA Professional Development Opportunities That E98 Teachers Completed

NES Summer Orientation*
National Middle School Conference, Philadelphia, PA*
National Educational Computer Conference, Philadelphia, PA*
Workshops*
Technology Immersion Workshop*
Mississippi Educational Computing Conference 2005***
NECC**
National Middle School Conference**

* Source: 2006 Spring Team Interview
** Source: Spring 2006 Team Lead Survey
*** Source: Fall 2005 Team Lead Survey

Table 4
NASA (and NASA-affiliated) Resources Used

Return to Flight
Mission Mathematics
NASA coordinator support
AES support
NASA materials
NASA hands-on activities

Source: 2006 Spring Team Interview

Table 5. E98 MCT Grade 6 Scores

	Reading	Language Arts	Math
2003	45%	30%	18%
2004	48%	43%	34%
2005	44%	41%	27%
2006	53%	38%	47%
State Average in 2006	75%	63%	73%

Source: MCT Results. (2005-2006). Mississippi Dept. of Education. Downloaded 04-27-2007 from http://www.mde.k12.ms.us/

Table 6. E98 MCT Grade 7 Scores

	Reading	Language Arts	Math
2003	22%	22%	12%
2004	38%	39%	18%
2005	42%	35%	24%
2006	29%	35%	19%
State Average in 2006	59%	57%	57%

Source: MCT Results. (2005-2006). Mississippi Dept. of Education. Downloaded 04-27-2007 from http://www.mde.k12.ms.us/

Table 7. E98 MCT Grade 8 Scores

	Reading	Language Arts	Math
2003	24%	25%	23%
2004	23%	22%	21%
2005	29%	29%	25%
2006	30%	30%	40%
State Average in 2006	55%	50%	59%

Source: MCT Results. (2005-2006). Mississippi Dept. of Education. Downloaded 04-27-2007 from http://www.mde.k12.ms.us/

NASA Explorer Schools Case Study Profile: F87
2004 Cohort—Small Town, North Dakota Public Middle School: Grades 5-8

Summary Comments Regarding F87
F87 is a Native American, off-reservation, boarding school that services approximately 200 students in grades 5-8 and is located in a small town in North Dakota. Each year there are a number of different tribes represented in F87. The student population is comprised of anywhere from 25 to 33 tribes from 14 to 17 states. Truancy and kicked out of their home school district are two of the main reasons why students are attending F87. Many students are at F87 because the school has a great caring staff with a lot of special education qualifications. There are 60-70 percent identified with special educational needs as defined by PL105-17 and reauthorized by the Individuals with Disabilities Improvement Education Act (PL107-110). In 2004-2005 the school qualified as Title I school.

With the student population at F87 coming from a variety of tribal backgrounds and the learning taking place in a residential school campus, this case provides an example of NES implementation in a truly unique setting. As a school serving American Indian students exclusively, F87 faces some additional academic challenges. A spring 2006 Nations Report Card[1] assessing student performance among American Indian students shows that for grades 4 and 8, American Indian/Alaska Native students had lower average scale scores in reading than all other students in the nation (students who are neither American Indian nor Alaska Native). The percentages of students performing at or above Basic and at or above Proficient were also lower for American Indian/Alaska Native students than those for all other students at both grades.

Here are some of the successes that F87 achieved during its three-year period as a NASA Explorer School:

- F87 increased teachers' understanding of content knowledge and inquiry teaching strategies.
- F87 teachers carefully addressed different learning styles and academic levels in each instructional unit. For example, students' varying attention spans and abilities are accommodated by hands-on and interactive enrichment materials.

As a school that serves a predominantly underserved population, F87 must overcome challenges that compete with STEM-G-related reform activities for teacher and administrator attention. Here are some of the challenges:

[1] The National Indian Education Study is available for download at http://nces.ed.gov/nationsreportcard/nies/l0101.asp#selected

- Changes in the team members and the original team lead since the project started. New members have not received any training, and they are having a difficult time catching up with the implementation schedule. The loss of the team lead has also caused delays. The school felt that NASA could have been more helpful with this situation. If this situation happens again, NASA should address it and provide some recommendations to the school.
- A lot of NASA activities require huge amounts of class time to implement. If teachers would like to implement NASA activities, they have to sacrifice in-class time currently allocated to other activities.

We examined schoolwide achievements at F87 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcript of a focus group interview conducted by telephone with the F87 NES team. The interview was conducted May 11, 2006. We have also used the school website, survey data, NASA Explorer School e-Folio website, and U.S. Department of Education school data to expand upon information provided in the interviews.

Outcome 1: Increased participation and professional growth of educators in science.

The F87 NES team consists of an administrator, who also serves as the academic lead and is also a grades 5-8 gifted teacher and librarian; a grades 7-8 science teacher; a grade 7-8 math teacher who is also responsible for parent activities; a fifth grade teacher of all subjects; and the team lead, who teaches grades 5-8 computer skills. The team lead and grades 7-8 science teacher are both new to the team. In the May 11, 2006, focus group interview, a team member said, "The five people we have work very well together. The most positive thing is the leadership that has emerged from being on the team." Another team member said, "We work together, we are dedicated, and this team was the top of the crop" (Focus Group Interview, May 11, 2006).

The next section examines the extent to which the F87 school implementation of NES addresses the six guidelines for professional growth and development described below:

Guideline 1. Instructional Strategies.

- One of the team teachers at F87 reported that the professional development training has taught her to plan, implement, and evaluate more efficiently and effectively in every aspect of her teaching. Specifically, she mentioned that learning styles, differentiated instruction, and the backward design model assisted her in increasing individual

student performance. This teacher also shared her prediction that technology will pave the road to learning in the 21st century. [2]

- F87 NES teachers have taken advantage of the many NES opportunities. One team member said, "I now have more of a desire to learn and focus on NASA than I had prior to the program" (Focus Group Interview, May 11, 2006).
- The F87 NES team has gradually made plans to adopt several NASA activities. According to one team member, "We went with a monthly calendar of events. We picked a NASA day, picked topics, and then go with information on that day. We had themes for the day, such as aerospace, weather, robotics, telescopes, ISS, wind tunnels, NASA jobs and careers, and design challenge. We do one per month" (Focus Group Interview, May 11, 2006).

In addition to our analyses from the case study, we report some key findings from the survey data on F87. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings.

- When asked how often students in this class do hands-on/laboratory activities, five teachers responded "1-3 times per month," one responded "1-3 times per week," and one responded "sometimes" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often students in this class work in small groups to come up with joint solutions or approaches to a problem or task, three teachers responded "1-3 times per week," one responded "1-3 times per month," and three responded "sometimes" in the TLC survey.
- Here is how teachers responded to questions in the TLC survey regarding how often F87 teachers accomplish the following goals:
    - Elicit students' ideas and opinions: Two teachers responded "always," four responded "very often," and one responded "often."
    - Get students to justify and explain their reasoning: Two teachers responded "always," four responded "very often," and one responded "sometimes."
    - Have students relate what they are working on to their own experience: Five teachers responded "very often," and two responded "sometimes."
- Five teachers completed the Teacher Need and Involvement survey. In responding to how much they anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, one

[2] Source retrieved March 29, 2007, from http://quest.nasa.gov/projects/spacewardbound/

teacher said "a lot," two responded "quite a bit," one responded "some," and one responded "a little."

Guideline 2. Time Intensive.

- One of the F87 NES team members was selected as top teacher for a new NASA education program called Airspace Systems Education Cohort (ASEC). The airspace systems education teachers represent an impressive array of skills, interests, and backgrounds that will serve NASA, their students, and their colleagues well as they return to their districts. The selected teachers toured a variety of airspace system facilities, including the Crew Vehicle System Research Facility, Future Flight Central, and the Air Traffic Control Research Laboratories. They heard presentations by NASA researchers and observed demonstrations of advanced research and technology related to airspace systems. They also participated in a variety of hands-on workshops to become trained in the related NASA educational activities. [3]
- The professional development opportunities are shared schoolwide. The F87 team strived to encourage non-NES teachers to attend some professional development workshops. For example, as a team member said in the interview, "One of the [non-NES] teachers will be going to the training this summer. One will go to Chile and look at how water affects life. The opportunities are shared. Our staff development has improved. The teachers have voluntarily requested professional development for themselves and other schools in their community" (May 11, 2006).
- The professional development is intensive. An F87 teacher said, "I just got back from a conference in San Antonio and got a lot of information and made connections. We communicate now with people we met at the conference through e-mail. We would never have had that without the program" (Focus Group Interview, May 11, 2005).
- The F87 NES team perceived the importance of professional development and continued to seek out opportunities for professional growth. "Probably most importantly is that NASA gives us the opportunity to go to conferences, which allows networking, and we get connections, and we find out who to contact to get answers" (Focus Group Interview, May 11, 2006).

When asked in the Teacher Involvement survey (Spring 2006) about their level of involvement in the NASA Explorer Schools program, here is a summary of F87 teacher responses:

[3] Source retrieved March 28, 2007 from http://www.nasa.gov/centers/ames/spanish/news/releases/2004/05_42AR.html

- How many NASA STEM-G activities have you used in your classroom this year? One chose 6-15, two chose 6-15, and one chose 1-5.
- How much have you participated in the following NASA activities this year?
    - Professional development: All chose 1-5 times.
    - Schoolwide events: Three chose 1-5 times, and one chose 6-15 times.
    - Use of NASA materials in your own classroom: One chose 30+ times, one chose 16-30 times, one chose 6-15 times, and one chose 1-5 times.
    - Shared what you learned with your colleagues: Two chose 6-15 times, and one chose 1-5 times.
    - DLN events: Four chose not at all.

When asked, "How much do you agree with the following?" F87 teachers responded with the following ratings:

- The NES program has been a valuable experience for you: Three chose "a lot," and one chose "some."
- This program has been inspiring to you: Three chose "a lot," and one chose "some."
- You applied what you learned from being a part of the NES program: Three chose "a lot," and one chose "a little."
- You integrated NASA-related materials into your curriculum. Two chose "a lot," one chose "quite a bit," and one chose "some."
- This program has been inspiring to students: Two chose "a lot," one chose "quite a bit," and one chose "a little."
- The NES program has been a valuable experience for students: Two chose "a lot," one chose "quite a bit," and one chose "a little."

The averages for the F87 ratings to the first four questions are above the overall case study means. F87 ratings are below the overall case study means for the last two ratings.

Guideline 3. Classroom Practices.
An F87 teacher received special training for new Airspace Systems Education Cohort. The ASEC program uses a train-the-trainer model of professional development to engage teachers in scientific inquiry at the leading edge of education and technology. After attending tours, lectures, and workshops at the ASEC Summer Institute, the teachers return to their educational communities to train others in the use of NASA-developed classroom materials.

Guideline 4. Content Knowledge.

Of the professional development offered, one teacher said, "I found I got a lot of helpful information and lots of activities for the classroom" (Focus Group Interview, May 11, 2006). The F87 teacher involved in the Airspace System Education program is getting concentrated professional development in science and technology that will be shared with students and faculty through additional classroom activities and extended learning opportunities.

When asked in the Teacher Involvement survey (Spring 2006), "How comfortable are you teaching concepts in the following areas?" the F87 team responded with the following comfort ratings (5 = a lot; 1 = not at all):

- Science: One selected 5, two selected 4, and one selected 3. Mean rating = 4.
- Educational Technology: Two selected 3, and one selected 1. Mean rating = 3.33.
- Engineering/Technology: Two selected 3, one selected 2, and one selected 1. Mean rating = 2.25.
- Mathematics: One selected 5, and three selected 4. Mean rating = 4.25.
- Geography: Three selected 4, and one selected 3. Mean rating = 3.75.

The F87 team ratings for their confidence in teaching mathematics is above the overall case study mean rating of 3.94. In each of the other areas, F87 is below the case study survey mean.

Guideline 5. Active learning.
The F87 team projected in its NASA e-Folio website that it plans to use the NASA solar system curriculum to display scientific knowledge for enrichment purposes. Students will also experience the field trip to the state planetarium, which emphasizes the Native American connection through legends and the medicine wheel.

Guideline 6. Coherence.

- NASA activities are aligned with school curriculums, which has eased implementation processes. As a NASA Explorer School, F87 not only received financial support to purchase technology equipment, but also learned to use the equipment to teach effectively. A teacher said, "the material of the program works well in the classroom for what I want to teach" (Focus Group Interview, May 11, 2006).
- The NES F87 team conducts an annual evaluation to ensure that the school meets its NASA strategic guidelines. A teacher said that "the program has been a real asset to our school. We also evaluate through accreditation processes. We tie in the NES activities into our documentation" (Focus Group Interview, May 11, 2006).

- The field center coordinator scheduled action planning at the end of the workshop day to facilitate the teachers on integrating what they had seen during the day into their strategic plan or curriculum. He also scheduled reflection time so that the teachers would think about how NES aligns with the reform efforts they are doing at their school.
- The F87 team projected in the NASA e-Folio website that it plans to use the NASA solar system curriculum to display scientific knowledge for enrichment purposes. The activity covers and aligns with state standards on Earth in the solar system.

Summary of How F87 Meets Outcome 1.
The NES F87 team has worked collaboratively to meet the goals of the NASA Explorer School program. Although there have been changes in the team, the team strives to overcome the challenge quickly and concentrate on how to benefit the most from the NES program. For example, teachers attend professional development workshops and conferences to network and make connection with other educators, which they were not able to do before becoming a NASA Explorer School. The NES F87 team has achievements to some extent in each guideline outlined as indicators for a successful implementation. The support from field center staff and NASA education specialists has helped teachers to fully utilize the resources. Teachers are able to adapt what they learn to meet the needs of individual students.

Outcome 2. Increased assistance for and technology use by educators in schools with high populations of underserved students.

The F87 team purchased the following technologies with NES funding:
- Robotics
- Videoconferencing equipment
- GPS

F87 teachers introduced students to the use of GPS technology and plan to integrate this technology into an activity in which students create a map that displays river pH levels and turbidity. As the F87 teachers explain in their digital portfolio, "The local river has a food processing factory, and the student will be using probes provided by NASA to measure pH levels and turbidity every ½ mile for 2-3 miles upstream and downstream. The students will be using GPS units to record each spot of measurement and to accurately measure each ½ mile. The data and data points the students collect will be used to make a map of their research results. Mapping software will allow the students to make a map. The students will be placed in groups of 3-4 people." As of July 16, 2007, teachers have not reported on the outcome of this planned activity. In their online plan they discuss starting out using GPS with a smaller scale on-campus activity to

prepare students for the more advanced project. This scaffolding process would be helpful for the teachers as well as the students.

The NES evaluation team also incorporated some of the data from the Teaching, Learning, and Computing (TLC) and Teacher Need and Involvement surveys to generate a more inclusive picture of how F87 teachers integrate technology. When teachers were asked how many days a year a typical student in the class uses a computer while they are teaching their class, teachers responded "20-40 times (equally to weekly) times" a year. Teachers also responded "6-15 times" for using NASA materials in their classroom in a year.

Outcome 3. Increased family involvement in children's learning.

F87 initiates several events that involve parents to participate in their students' learning. For example, the F87 team used the NASA education specialist to the fullest potential. Neighboring schools were invited to participate when a NASA education specialist visited the school for a week. Parent Day was also scheduled during the visit so that parents could receive some outside resources.

Parents of F87 students have actively participated in the school events. One of the F87 team members said that "parents came to the school once per year. They come once and do all activities with the children. We meet regularly for short periods of time. We meet every two weeks for 15 minutes" (Focus Group Interview, May 11, 2006). The field coordinator also observed that the increase in family involvement might be because of the teacher professional development so that the teachers can be more engaging with the families during science night.

Outcome 4. Increased student interest and participation in STEM-G.

Students at F87 have shown increased interest in STEM-G through participating in different activities, particularly when innovative technology tools were involved. Students were inspired and excited about what they can accomplish in their future. The following strands are indicators of what it means for students to have interest and to participate in STEM-G activities. Students who are interested and participate in STEM-G activities have the tendency to:

Participate productively in STEM-G practices and discourse.
"NASA has brought many attainable activities to the students that they would not normally have participated in until they got to high school" (Focus Group Interview, May 11, 2006).

As input in the NASA e-Folio website, students are encouraged to participate in numerous NASA-related hands-on activities. For example:

- Mars Design Challenge is an activity in which students designed a living and working environment on Mars. Students needed to apply appropriate techniques, tools, and formulas to determine measurements.
- Students participated in the NASA solar system curriculum as an enrichment activity during after-school hours. Students experienced a field trip to the Valley City State Planetarium, which emphasizes the Native American connection through legends and the medicine wheel.

Noticeable curiosity in STEM-G topics and events.
"It has inspired us. It gives us a new focus. Students are truly intrigued by finding out that their generation will be the one going to Mars" (Focus Group Interview, May 11, 2006).

As found in the F87 school e-Folio, teachers tried to incorporate activities that students would not normally be exposed to. For example, an entomologist from NDSU brought in tarantulas, Madagascar hissing cockroaches, North American scorpions, and Central American millipedes and presented the animals to the students and taught them about the animals. Students had the opportunity to hold these animals and ask questions about them. It had helped to alleviate misinformation about these animals as well as inform the students about what can be found in other parts of the world.

Attitudes changes about science learning.
"Students are very excited about the Science Fair this year. It is much improved. They learned that things work out better if you prepare, not just punt. Students see that scientists practice skills over and over again" (Focus Group Interview, May 11, 2006).

Active participation in hands-on and authentic scientific research.
The solar system lithograph set will be displayed and used as a reference in the NASA solar system curriculum. The students will use a telescope as an enrichment activity during and after school hours. [4]

As stated on the NASA e-Folio website, students are encouraged to participate in numerous NASA-related hands-on activities. For example:

- In Mapping with GPS, students are asked to collect, organize, and display relevant data to answer questions. Students use GPS units to record each spot of measurement and to accurately measure each ½ mile. The data and data points the students collect are used to make a map of their research results.

[4] Source retrieved March 30, 2007 from NASA e-Folio website

- In the Mapping Water Quality activity using GPS, students measure pH levels and turbidity of the local river upstream and downstream from a local food processing plant (and possibly a power plant) by using the probes. The students make these measurements at ½-mile increments upstream and downstream from the river for 2 miles each direction. The students also use the GPS units that NASA has provided to pinpoint the locations of where their measurements were taken as well as to get the ½-mile increments closely aligned. After the data from the probes has been recorded from each test site, the GPS units are used with mapping software to make a map showing the pH and turbidity levels for each test site.

An F87 teacher said, "We have used the robotics activities and hands-on activities, and that has really made a difference in student achievement" (Focus Group Interview, May 11, 2006).

Outcome 5. Increased student knowledge about careers in STEM-G.

The F87 NES team has brought in several activities that are intended to increase student knowledge about careers in NASA. The following strands indicate students' knowledge about careers in STEM-G. Students who demonstrate knowledge about careers in STEM-G also demonstrate:

Change in self-identity.
"[F87] student body is totally Native American and 70 percent special education and come from all over the United States. This presents concerns in the classroom. You always have to keep this in mind. NASA had materials for every academic level. F87 is a unique learning opportunity and this is important to remember when answering these questions" (Focus Group Interview, May 11, 2006).

Increase understanding of and enthusiasm about STEM-G careers.
In January the portable planetarium was brought to the campus for enrichment purposes. Students experienced a field trip to the Valley City State Planetarium, which emphasized the Native American connection through legends and the medicine wheel.[4]

An F87 teacher said, "We have lots of career awareness. One of our students won a NASA art contest, and our school was part of the Line Up with Math pilot program" (May11, 2006).

Outcome 6. Increased student ability to apply STEM-G concepts and skills in meaningful ways.

As found in the school e-Folio website, teachers have planned activities and opportunities for students to experience real-world problem solving using NASA resources and technologies.

Understand and use scientific explanations of the natural world in context of a problem-solving activity.
Students used a GPS technology tool to measure and locate pH levels and turbidity of the local river upstream and downstream.

Students used GPS to plot direction and distance to determine their exact position on the earth's surface. The purpose of this activity is to introduce students to the technology and apply the information to daily living. 5

Understand how to use and interpret the data obtained from technology tools to support STEM-G-related inquiry activities.
Students are asked to collect, organize, and display relevant data to answer questions.

Demonstrate increased performance in STEM-G and related subjects, like language arts.
An F87 teacher observed that the use of NASA hands-on activities has made a difference in student achievement. Tables 5-7 display the most recent student achievement scores in math, reading, and language arts from grades K-8.

The National Council for Education Statistics published a study of American Indian Achievement, which provides more information about how achievement scores among this population group are being collected and reported.[i]

[5] Source retrieved March 30, 2007 from, NASA e-Folio website.

Table 1. School Demographics

	2002-2003	2003-2004	2004-2005	2005-2006
Student Population				
Black, non-Hispanic	0**	0**	0**	0**
Asian	0**	0**	0**	0**
Hispanic	0**	0**	0**	0**
American Indian, Alaskan Native	100%**	100%**	100%**	100%**
White, non-Hispanic	0**	0**	0**	0**
School Location (rural, suburban, urban, large central city)				
School Type (public, private, charter, magnet)				
Title 1 status (yes or no)			Yes*	
English Language Learners				
Free and Reduced Price Lunch				
Teacher Population				

Note: Grayed-out cells indicate that data is not available as of March 14, 2007.

* Source: *Common Core of Data (CCD), Public Elementary/Secondary School Universe Survey," 2002-03 v.1a, 2003-04 v.1a, 2004-05 (Preliminary) v.0f-preliminary*. National Center for Education Statistics (NCES). (Date not provided). Retrieved March 14, 2007, from http://nces.ed.gov/

** Source: NES 2006 Spring Team Interview. *"[F78] student body is totally Native American and 70 percent special education and come from all over the United States."*

Table 2. Summary of Academic Needs Identified by F87 in 2004

Priority	Discipline	Category	National Standard
1	Principles and Standards for School Mathematics	Number and Operations	Compute fluently and make reasonable estimates.
2	Principles and Standards for School Mathematics	Communication	Analyze and evaluate the mathematical thinking and strategies of others
3	Principles and Standards for School Mathematics	Algebra	Represent and analyze mathematical situations and structures using algebraic symbols
4	Principles and Standards for School Mathematics	Measurement	Apply appropriate techniques, tools, and formulas to determine measurements
5	Principles and Standards for School Mathematics	Data Analysis and Probability	Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
6	National Science Education Standards	Earth and Space Science	Structure of the Earth system
7	National Science Education Standards	Earth and Space Science	Earth in the solar system
8	National Science Education Standards	Life Science	Structure and function in living systems
9	National Science Education Standards	Physical Science	Motions and Forces
10	National Science Education Standards	History & Nature of Science	Science as a human endeavor.

Source: F87 Needs Assessment. (2004).

Table 3. NASA Professional Development Opportunities That F87 Teachers Completed

Conference, San Antonio, TX*
Chile Expedition*
Math Space Station Camp*
Conferences*
NES summer orientation workshop***
NES update session during NSTA***
NSTA***
Teacher trainings**
National Science Conference, CA** (2)
National Math Conference (1)**
Administrative Conference (1)**

* Source: Spring 2006 Team Interview
** Source: Spring 2006 Team Lead Survey
*** Source: Fall 2005 Team Lead Survey

Table 4. NASA (and NASA-affiliated) Resources Used

Line up with Math pilot program*
Robotics*
Hands-on activities*
Webcasts*
Materials**
Visits from NASA representatives**
GPS****

* Source: Spring 2006 Team Interview
** Source: Spring 2006 Team Lead Survey
*** Source: Fall 2005 Team Lead Survey
**** Source: NASA e-Folio website

Table 5. NES F87 Math Achievement Scores[1]

Year	Grade	Basic	Proficient	Advanced
2002-2003	**K-8**	49.60%	47.20%	3.20%
2003-2004	**K-8**	36.92%	61.54%	1.54%

Table 6. NES F87 English/Language Arts Achievement Scores[1]

Year	Grade	Basic	Proficient	Advanced
2002-2003	**K-8**	43.2%	52.8%	4%
2003-2004	**K-8**	30.77%	66.92%	2.31%

Table 7. NES F87 Reading Achievement Scores[1]

Year	Grade	Basic	Proficient	Advanced
2002-2003	**K-8**	35.2%	63.2%	1.6%
2003-2004	**K-8**	26.15%	70.77%	3.08%

[1] NCES National Indian Education Study, Part I: NAEP 2005 Performance by American Indian and Alaska Native Students. May 24, 2006.

The National Indian Education Study (NIES) is a two-part study designed to describe the condition of education for American Indian/Alaska Native students in the United States. The study was conducted by the National Center for Education Statistics (NCES) for the U.S. Department of Education, Office of Indian Education (OIE).

Part I of the study presents the performance of American Indian/Alaska Native students at grades 4 and 8 on the 2005 National Assessment of Educational Progress (NAEP) reading and mathematics assessments. Approximately 7,200 American Indian/Alaska Native students participated in reading and 7,300 in mathematics. This national sample includes students from both public and nonpublic schools. In addition to the national sample, states with relatively large populations of American Indian/Alaska Native students as a percentage of the state's total population are included in the report (Alaska, Arizona, Montana, New Mexico, North Dakota, Oklahoma, and South Dakota).

Findings are detailed and discussed in the report, including these for the NAEP 2005 reading assessment:

* At both grades 4 and 8, American Indian/Alaska Native students had lower average scale scores compared to all other students in the nation.
* The percentages of students performing at or above Basic and at or above Proficient were also lower for American Indian/Alaska Native students than those for all other students at both grades.
* At grades 4 and 8, American Indian/Alaska Native students in Oklahoma had higher average reading scores than all American Indian/Alaska Native students in the nation.

Findings for the NAEP 2005 mathematics assessment include these:
* At both grades 4 and 8, American Indian/Alaska Native students had lower average scale scores than all other students in the nation.
* The percentages of students performing at or above Basic and at or above Proficient were also lower for American Indian/Alaska Native students than for all other students at both grades.
* At grade 4, the average scores for American Indian/Alaska Native students in Montana and Oklahoma were not significantly different when compared to American Indian/Alaska Native students in the nation. At grade 8, American Indian/Alaska Native students in New Mexico and South Dakota had lower average scores than all American Indian/Alaska Native students in the nation.

Part II of the study, which is a survey of the educational experiences of American Indian/Alaska Native students, their teachers, and their schools, will be released in the summer of 2006.

To see complete results, go to:
http://nces.ed.gov/nationsreportcard/NIES

You may download the full report from:
http://nces.ed.gov/nationsreportcard/pdf/studies/2006463.pdf

NASA Explorer Schools Case Study Profile: H16
2004 Cohort—Urban, New York Public Middle School: Grades 6-8

Summary Comments Regarding H16
H16 is public elementary school located in the middle of a large city. The student population of approximately 493 students is predominantly minority (98%) with 77% of the students qualifying for free or reduced lunch. H16 is in its second year of school restructuring status. The H16 school building is now composed of four distinct thematic programs: a school for the arts, academics, a cybertech, and a science museum partnership. Having these core themes permits a high degree of flexibility in planning and implementing rich academic and arts programs. Each program shares a common vision: to provide each student with the personal attention and teacher-student interaction crucial to a middle school student's growth and development. In this current year, H16 is one of several schools in its area to participate in a one-year technology education initiative in which each student receives their own laptop for one year. This program is sponsored by the city council committee on technology in government. Additional demographic details are provided in Table 1.

Here are some of the successes that H16 achieved during its three-year period as a NASA Explorer School:

- H16 created a new NASA Science Club called the Ambassadors.
- H16 created a new Beginner's Invention Club.
- H16 developed partnerships with the Natural History Museum and Columbia University.
- H16 developed a relationship with a local council member who provided laptops for all 6th graders.

As a school that serves a predominantly poor population H16 must overcome challenges that compete with STEM-G-related reform activities for teacher and administrator attention. Here are some of these challenges:

- The two original team members (the team lead and school administrator) who were most enthusiastic about the NES program left the school, and only one member of the original H16 NES team remains.
- H16 has experienced high turnover in teachers, staff, and administrators schoolwide. To illustrate how disruptive the turnover can be, H16 has had three principals in a single year in addition to loss of faculty members.

We examined schoolwide achievements at H16 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcript of a focus group interview conducted by telephone with the H16 NES team on May

26, 2006. We have also used school website, survey data, and U.S. Department of Education school data to expand upon information provided in the interviews.

Outcome 1. Increased participation and professional growth of educators in science.

The NES H16 team was formed in 2005 with five members, but was rebuilt in 2006 with four new members (one who joined and was replaced in 2006) including a new team lead. The current team includes a 6th grade science teacher, a 6th grade social studies teacher, an unidentified grade/subject teacher, and a school administrator who currently serves as team lead. Table 2 provides a list of the academic needs the startup team identified when first joining the NES project. During its NES participation H16 developed strategic and implementation plans that showed how it would address these academic priorities through the NES project. The NES team and its students have generated a variety of new NASA-affiliated activities at their school including a NASA Science Club (called The Ambassadors), robotics, and a beginner's invention club. Tables 3 and 4 provide a summary of the professional development opportunities and NASA resources that H16 has taken advantage of as a NASA Explorer School.

The next section examines the extent to which the H16 school implementation of NES addresses the six guidelines for professional growth and development described below.

Guideline 1. Instructional Strategies.

The H16 team has been successful in building connections with large universities and museums not far from the school that have extensive STEM-G resources and expertise that can help link the activities and content made available through NES to local institutions and research centers. Here is one example of how H16 has been lucky to link with partners who can offer rich experiences to further student interest in STEM-G topics and careers.

- "Students were invited to a [local university] spectroscopy lab, to see demonstrations of lasers. They participated in a mini-lesson on light waves, reflection, polarization refraction and diffraction. They saw how a spectroscope can use different wavelengths of light to penetrate and identify different materials. They saw an atomic microscope, which can photograph molecules. They also witnessed the creation of laser crystals."[1]

[1] Source: NASA Explorer School Digital Portfolios. Retrieved July 20, 2007, from http://aesp.nasa.okstate.edu/efolio

From another perspective, this H16 teacher describe how being a NES teacher has allowed him (or her) to teach specific science topics of great personal interest that did not directly link to his assigned teaching focus.

- "Being able to not limit myself in class has been great. I can talk to my students about science. I am a social studies teacher, but now I can talk and teach and incorporate science into social studies. I have always been interested in Earth Science and space so I was 'over the moon' when asked on to be on the team" (Focus Group Interview, May 26, 2006).

In addition to our analyses from case study, we report some key findings from the survey data on H16. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings.

- When asked how often do students in this class take part in doing hands-on/laboratory activities, one teacher responded "almost everyday," and the other responded "1-3 times per month" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often do students in this class take part in working in small groups to come up with joint solutions or approach to a problem or task, both two teachers responded "1-3 times per week."
- Here is how teachers responded to questions in the TLC survey regarding how often H16 teachers accomplish the following goals:
    - Elicit students' ideas and opinions: One teacher responded "very often," and the other responded "always."
    - Get students to justify and explain their reasoning: Both teachers responded "always."
    - Have students relate what they are working on to their own experience: One teacher responded "very often," and the other responded "always."
- Only one teacher completed the Teacher Need and Involvement survey. In responding to how much he or she anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, this teacher responded "some."

Guideline 2. Time Intensive.

- "We have talked to people to get them to be on the new team. We have the enthusiasm of the new team members. We are starting over in a sense. We have people in English and Social Studies now on the team" (Focus Group Interview, May 26, 2006).
- "As for roles, [One of the team teachers] is the resource person. She is good about going on a website and giving us sites" (Focus Group Interview, May 26, 2006).

- "[A science teacher on the NES team focuses on] science. and at first he was like "NASA will come in and do things" (Focus Group Interview, May 26, 2006). Later he saw that the NES project wasn't just about NASA activities, resources, and materials; he saw that it required him to rethink how he taught science.
- The team responded, "This was somewhat easy" when asked how they found working with the school administrator to make systematic program changes when things worked for a teacher or group of students. "Usually if we have schedules, then we would try to have other teachers present to see the activity and how to implement it in their classroom" (Focus Group Interview, May 26, 2006).
- "It has helped them to see that science was not the third cousin to every other subject. Sometimes we get caught up in test scores for English and math" (Focus Group Interview, May 26, 2006).
- "It did spark an interest in teachers for the program" (Focus Group Interview, May 26, 2006).

When asked how the team is evaluating the impact of the school strategic plan, the team responded, "One of the tings we want to do is look at our objectives and see what we planned and what we did and didn't do. We are doing surveys with the kids. I am looking at making Year 2 into Year 3 and year 3 into Year 4 after that. I know what happened and we will try to move on from here. I would say to everyone and to NASA that the program is worth it. It touches lives, it is great. It is worth doing it with other schools. This is bittersweet because we know we didn't get to do everything" (Focus Group Interview, May 26, 2006).

- Six twice-weekly sessions of Astro-venture professional development were offered to H16 teachers. "Internet science program that explored astronomy, geology and biology, culminating in a creating a planet that could sustain life."[1]

- One H16 teacher attended the SECC Conference. "A conference focusing on sustaining human life in space. Space exploration in the future. Applying space exploration into the everyday middle school science curriculum."[1]

Guideline 3. Classroom Practices.
The H16 teachers explain that in spite of their staff turnover they do understand what is expected of them as a NASA Explorer School.

- "They [NASA managers who oversee this program] want us to look at the curriculum and see what we can integrate" from the materials that have been demonstrated at the professional development programs and by way of our aerospace education specialists (Focus Group Interview, May 26, 2006).

- "Up to this time, we had people come and assist in different lessons. They asked for different lessons I would do and they did their own labs. These were presentations to the students, but there were times when teachers got to meet with the [AES] person. He came once a week for the first 1 ½ years. It happened all the way through December of this academic year" (Focus Group Interview, May 26, 2006).

Guideline 4. Content Knowledge.

- "Being able to not limit myself in class has been great. I can talk to my students about science. I am a social studies teacher, but now I can talk and teach and incorporate science into social studies. I have always been interested in Earth Science and space so I was 'over the moon' when asked on to be on the team" (Focus Group Interview, May 26, 2006).
- "It has shown me what NASA really involves. I found out all the different things NASA has pioneered within their space program" (Focus Group Interview, May 26, 2006).

Guideline 5. Active Learning.

- "The [AES] person and I had weekly meetings to arrange a schedule of going to classrooms. We are now doing a very NASA intensive project. We wish he were here now to supplement the project. The project is on ecosystems on Earth and in space. Because of the changes, we didn't have a stable environment for him to come" (Focus Group Interview, May 26, 2006).
- "I would like more hands-on material from NASA and more satellite images. We do geography project and basic Earth Science and in Earth history, NASA doesn't have a lot of stuff geared toward social studies and history. They are all geared toward the future. I hope to incorporate NASA materials into more classes next year" (Focus Group Interview, May 26, 2006).
- "Another problem is how to incorporate materials into the curriculum they have to teach, and to do it without invading the territory of the science teachers. We definitely talk to other teams and other faculty. We have teachers willing to give up class periods for a project that needs more extended times" (Focus Group Interview, May 26, 2006).
- "All our 6th grade teachers collaborate" (Focus Group Interview, May 26, 2006).
- "We have 44 minute classes and it's nice to get other teachers involved" (Focus Group Interview, May 26, 2006).

- "With our new principal, there will be even more integration among the four core curriculum subjects" (Focus Group Interview, May 26, 2006).
- "We met once per week after school for one hour. We talked about the activities we would do and used the time to talk about what we needed the [AES] person to do. We planned if we could do a career day again" (Focus Group Interview, May 26, 2006).
- "This year, we will meet every Friday at 9:30 am and not after school. We need to get the principal on track with the program" (Focus Group Interview, May 26, 2006).

Guideline 6. Coherence.

One strategy used by H16 to leverage NASA support was to bring in outside speakers who had experience in different STEM-G-related areas to come and talk to the students"The team got together and found people who could come and talk" (Focus Group Interview, May 26, 2006).

- "Our tech person has changed. We have laptops now so we can do things now that we couldn't before. Very little technology came from NASA. We received a gift from Councilwoman Gail Brewer who gave laptops to all 6th graders" (Focus Group Interview, May 26, 2006).

In terms of leveraging NES funding to pursue additional partnerships, the H16 school has been very successful. Here are some of the partners H16 lists on its 2006-2007 report card. "We have partnerships with the Museum of Natural History, Lincoln Center, Teachers College, Children's Museum of Manhattan, Society of the Educational Arts, Junior Achievement, The Tommy Hilfiger Foundation, and Chess in the Schools."

- "The other ladies, such as [teacher's name] have made connections with colleges because she is still a student. [Teacher] is connected with the museum" (Focus Group Interview, May 26, 2006).
- "We also had a collaboration with Columbia University…to talk about STEM-G careers" (Focus Group Interview, May 26, 2006).
- "Other people came in from the city school administration, NASA, and other organizations to participate in STEM-G activities" (Focus Group Interview, May 26, 2006).
- "We got $500,000 for a science lab to make the school a science magnet school. Our school did not have facilities so we got selected to get labs. The mayor of New York City has been working toward getting schools more technology. H16 being a NASA school really helped. They were picked as a science magnet school" (Focus Group Interview, May 26, 2006).

Summary of how H16 achieve outcome 1:
NES has helped H16 teachers to implement some of the science-related activities and given the teachers more flexibility in their teaching resources. The NES team consists of not only science and math teachers, but social science teachers are willing to be part of the team. The participation of NES program has inspired teachers to adopt new teaching methodologies. H16 school also establishes some partnership with the university and actively applies for other funding for professional development.

Outcome 2. Increased assistance for and technology use by educators in schools with high populations of underserved students.

The H16 team purchased the following technologies with NES funding:

- Laptops

We were able to retrieve some of the information about how H16 school incorporates NES technologies and technology-rich activities into their STEM-G curriculum.

- "Our tech person has changed. We have laptops..[and]…can do things now that we couldn't before. Very little technology came from NASA. We received a gift from Councilwoman Gail Brewer who gave laptops to all 6th graders" (Focus Group Interview, May 26, 2006).
- "Some of our teachers are using technology in order to bring NASA into their classrooms by allowing the students to do research on hurricanes, for example. The technology teacher will begin incorporating robotics in some of her classes and a beginner's invention club."[1]
- H16 had an activity "Using Memory Sticks in the Classroom." In the e-Folio, under NASA Resources used, H16 states, "Our school is part of a program, championed by city councilperson, [name], to have carts of laptops that are to follow students through their three year education at H16. Students are required to purchase a thumb drive, in order to insure that all students will have year long, shared access to the laptop carts. Sixth grade English/Language Arts students are taught how to use a thumb drive, memory stick. The students will have to use them for their middle school career. Students are taught that these thumb drives are hardware and have a specific way of being used." [1]

The CET NES evaluation team also incorporated some of the data from Teaching, Learning, Computing (TLC) and Teacher Need and Involvement surveys to generate a more inclusive picture of how H16 teachers integrate technology. When teachers were asked how many days a year does a typical student in the

class use a computer while they are teaching their class, teachers responded only "1-5 times" a year. Teachers also responded only "1-5 times" for using NASA materials in their classroom in a year.

Outcome 3. Increased family involvement in children's learning.
Searching for postings about H16 outreach and family events on the web, we found the following comments from H16 parents.[2]

> "There is much more control on discipline this year. The student-teacher ratio is excellent! Students are responding well to the increased attention. This school is definitely headed in the right direction. Many supplemental after school programs available. Parent participation is still very low" (February 2007).
>
> "The best thing about this school is the art classes. I enjoyed the teachers and the new things she learned in music and dance. I really hope to use this in the future except in real concerts and wont forget to mention where it all started" (April 2006).
>
> "I am impressed with t he language arts teachers here, especially [teacher]. The school has after school photography classes and kids are a little restless but respond well to teachers and generally respect each other" (May 2005).
>
> "avoid the school at ALL costs! only go here as a last resort when no other school wont accept your child. Believe me" (December 2004).
>
> " This had to be WORST school my child had ever attended!! As a parent, I am very concerned about the school leadership and future" (October 2003).

As documented in H16 e-Folio, H16 NES team has planned out several family involvement events that allow family to be a part of the learning community.

- "In an effort to interest students in our after school science club, we had an open invitation to 7th and 8th grade students to a frog dissection. Student

[2] The Great Schools website lists overall positive comments from parents of H16 students. (The Parent's Guide to K-12 Success. (1998-2007). Great Schools™. Retrieved June 20, 2007 from http://www.greatschools.net/).

worked in pairs to dissect a frog. Parents were invited to attend an assist their children" (e-Folio, 2007).

- "The Parents' Night activities will be set up in the cafeteria. The students and their parents will work on solving math and science related problems and create a presentation that shows their solution. These problems will be located in various stations in the cafeteria. The teachers will be the 'judges' and will also offer assistance, if needed. Food will be served and all families will receive a certificate of participation."[1]

Outcome 4. Increased student interest and participation in STEM-G.

Since the partnership with NES, H16 has received attention from a local organization on wanting to support students. H16 also started an afterschool science club in which the curriculum covers a wide range of science subjects and activities.

The following strands are indicators of what it means for students to have interest and to participate in STEM-G activities. Students who are interested and participate in STEM-G activities have the tendency to:

Participate productively in STEM-G practices and discourse
"Other people came in from the city school administration, NASA, and other organizations to participate in STEM-G activities" (Focus Group Interview, May 26, 2006).

- "We had a program with the museum before where kids went to the museum for four periods for intensive research" (Focus Group Interview, May 26, 2006).
- H16 established an After School Science Club. "The after school science club will initially be composed of 16-20 7th grade students who will be selected based on interest, grades and conduct. The club will meet twice weekly for 2 hours. These students will spend 8 plus weeks learning a series of experiments. They will then become ambassadors of the science club and recruit 6th graders. The club will be involved in approximately 25 projects. Twenty will be short and occur during single meeting sessions and 5 will occur over several club sessions. The projects will consist of 7 physical science, 6 chemistry, 5 astronomy, 4 life science and 3 earth science activities and/or experiments. Student members will then act as STEM-G ambassadors to select elementary schools within our community. They will present and/or demonstrate scientific experiments to promote interest in STEM-G subjects."[1]
- H16 established an afterschool robotics club which met for ten two-hour sessions. "The theme for this activity will be is that students learn and apply

program commands that direct responses from a remote device (robot). The actual activities will depend on the robotics sponsor associated with the club. Activities from different organizations vary in levels of programming required, complexity of robot construction, and complexity of robot responses."[1]

- "In an effort to interest students in our After School science club, we had an open invitation to 7th and 8th grade students to a frog dissection. Student worked in pairs to dissect a frog. Parents were invited to attend an assist their children."[1]

Students experience dissecting a frog for the first time.

Noticeable curiosity in STEM-G topics and events

- "Sixth grade technology students, after having studied the technological advances made possible by NASA, wanted to learn more about astronomy. We studied the photographic enhancement process that universal astronomical events are recorded with. We did photographic research to see what our universe looks like. Each student then chooses a different astronomical event and captured it on black paper with colored chalk. By researching and capturing these events students had a better understand of black holes, exploding stars and star clusters. This exercise also helped students to understand the vastness of time and space and better appreciate our little corner of the universe."[1]

Outcome 5. Increased student knowledge about careers in STEM-G.

H16 teachers have noticed changes in their students in terms of their interest in STEM-G. The astronauts would come in to the school and talk to the students about careers in NASA.

The following strands indicate students' knowledge about careers in STEM-G. Students who demonstrate knowledge about careers in STEM-G also demonstrate:

Changes in self-identity
"Students have been made aware that these careers are accessible to them. Students thought NASA was just astronauts" (Focus Group Interview, May 26, 2006).

Increase understanding and enthusiasm about STEM-G careers
"They [NASA] want us to be ambassadors for NASA. As a school committee, we can let students know about STEM-G careers. We should expose our students to careers so they know what's out there" (Focus Group Interview, May 26, 2006).

- "We had a career day when people came and talked about STEM-G careers" (Focus Group Interview, May 26, 2006).
- "We also had a collaboration with Columbia University and they came in to talk about STEM-G careers" (Focus Group Interview, May 26, 2006).
- "Tom Estill, from Goddard Space Center, came and introduced our 6th grade classes to the wonders of NASA. Mr. Estill spent the day giving a emonstration to each of our 6th grade classes. He explained NASA's purpose and its expectations for the future. He also brought along models, a replica space suit and a space sleep system. The students had a great time learning about the different technologies that have entered our daily life thanks to NASA. They also learned about the huge diversity of jobs that NASA offers all educational levels."[1]

Luther finds out what sleep is like in space.

Share information with their peers and parents

- H16 established an After School Science Club. "The after school science club will initially be composed of 16-20 7th grade students who will be selected based on interest, grades and conduct. The club will meet twice weekly for 2 hours. These students will spend 8 plus weeks learning a series of experiments. They will then become ambassadors of the science club and recruit 6th graders. The club will be involved in approximately 25 projects. Twenty will be short and occur during single meeting sessions and 5 will occur over several club sessions. The projects will consist of 7 physical science, 6 chemistry, 5 astronomy, 4 life science and 3 earth science activities and/or experiments. Student members will then act as STEM-G ambassadors to select elementary schools within our community. They will present and/or demonstrate scientific experiments to promote interest in STEM-G subjects."[1]

H16 Science Ambassadors showing 6th graders what the club is all about.

- "The Science Fair at H16 will allow students, parents, and the H16 staff to display the various teaching and learning activities that occurred during the school year. The science projects will demonstrate students' understandings of the how science, technology, mathematics, engineering, and geography influence our lives as well as motivate students to learn more about STEM-G careers. In addition, working on and completing the projects will provide an opportunity for students, parents, teachers, NASA staff, and local community organizations to work together in a safe environment that encourages effective teaching and learning."[1]

Outcome 6. Increased student ability to apply STEM-G concepts and skills in meaningful ways.

Students now present their science findings and share them with the rest of students at the science fairs. Because of the NES, H16 can host a science fair every year.

Understand and use scientific explanations of the natural world in context of a problem-solving activity.

- "It has opened up their eyes. It has helped them do work and do science work. Now, we are having science fairs again" (Focus Group Interview, May 26, 2006).

Understand how to use and interpret the data obtained from technology tools to support STEM-related inquiry activities.

- "We had a science fair for the first time in years" (Focus Group Interview, May 26, 2006).
- "Students were invited to the City University Spectroscopy lab to see demonstrations of lasers. They participated in a mini-lesson on light waves, reflection, polarization refraction and diffraction. They saw how a spectroscope can use different wavelengths of light to penetrate and identify different materials. They saw an atomic microscope, which can photograph molecules. They also witnessed the creation of laser crystals."[1]

Evidence is available to demonstrate student performance increased in STEM-G and related subjects like language arts.

Table 1. H16 School Demographics

	2002-2003	2003-2004	2004-2005	2005-2006
Student population		692*	541*	493*
Black, non-Hispanic		368*	319*	290*
Asian		16*	7*	8*
Hispanic		277*	202*	182*
Indian, Alaskan Native		6*	5*	3*
White, non-Hispanic		25*	8*	10*
School location (rural, suburban, urban, mid-size central city)		Large Central City**	Large Central City**	Large Central City**
School type (public, private, charter, magnet)		Public**	Public**	Public**
Title 1 status (yes or no)		Yes*	Yes*	Yes*
Free and reduced price lunch		74%*	77%*	77%*

* Source: New York State School Report Card. (2005-2006). New York State Department of Education. Retrieved June 20, 2007 from https://www.nystart.gov/publicweb-rc/2006/AOR-2006-310300010044.pdf

** Source: National Center for Education Statistics. (2007). Institute of Education Sciences, U.S. Department of Education. Retrieved June 20, 2007 from http://nces.ed.gov/ccd/bat/

Table 2. Summary of Academic Needs Identified by H16 in 2005

Priority	Discipline	Category	National Standard
1	Principles and Standards for School Mathematics	Problem Solving	Apply and adapt a variety of appropriate strategies to solve problems
2	Principles and Standards for School Mathematics	Data Analysis and Probability	Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
3	Principles and Standards for School Mathematics	Algebra	Understand patterns, relations, and functions
4	Standards for Technological Literacy	Technology and Society	Students will develop an understanding of the effects of technology on the environment
5	National Science Education Standards	Physical Science	Motions and Forces
6	National Science Education Standards	Life Science	Populations and ecosystems
7	National Science Education Standards	Physical Science	Transfer of Energy
8	Principles and Standards for School Mathematics	Measurement	Understand measurable attributes of objects and the units, systems, and processes of measurement
9	National Science Education Standards	Physical Science	Properties and changes of properties in matter
10	National Science Education Standards	Life Science	Reproduction and heredity

Source: J65 Needs Assessment. (2004).

Table 3. NASA Professional Development Opportunities that H16 Teachers Completed

Astro-venture professional development
Robotics training
Orientation Workshop
SECC Conference

Sources: 2006 Spring Team Interview; Spring 2006 Team Lead Survey; and, Fall 2005 Team Lead Survey

Table 4. NASA Resources and Expertise That H16 Teachers Incorporated into Their Instruction

NASA website
International Space Station
NES website
NASA-affiliated personnel
Earth Observatory
LandSat
Rose Center @ American Museum of Natural History
Goddard Space Flight Center
City College/CUNY
NASA space photography
NASA Funding
NASA satellite imagery
Robotics equipment
NASA-funded laptops
AES (via telephone or visit)
Goddard Space Flight Center staff
Resource book from orientation workshop that explains parent nights
NASA space shuttle training resources
NASA models
Space Center Houston
Johnson Space Center
NASA Literary Resources

Sources: 2006 Spring Team Interview; Spring 2006 Team Lead Survey; and, Fall 2005 Team Lead Survey

Table 5. H16 New York State Assessments - Grade 6 Scores

	English/Language Arts	Math
2004		
2005		
2006	15%	40%
2007	26%	
State Average in 2007	63%	60%

*Source: NYSED. (2006-2007). New York Department of Education. Downloaded 05-20-2007 from http://www.nysed.gov/

Table 6. H16 New York State Assessments - Grade 7 Scores

	English/Language Arts	Math
2004		
2005		
2006	14%	9%
2007	20%	
State Average in 2007	58%	56%

*Source: NYSED. (2006-2007). New York Department of Education. Downloaded 05-20-2007 from http://www.nysed.gov/

Table 7. H16 New York State Assessments - Grade 8 Scores

	English/Language Arts	Math
2004	14%	
2005	15%	
2006	15%	30%
2007	17%	
State Average in 2007	57%	54%

*Source: NYSED. (2006-2007). New York Department of Education. Downloaded 05-20-2007 from http://www.nysed.gov/

NASA Explorer Schools Case Study Profile: I16
2004 Cohort– Small Town, Alabama, Public Middle School: Grades 7 and 8

Summary Comments Regarding I16
I16 is a public middle school serving approximately 552 seventh and eighth grade students in the state of Alabama. The school is located on property adjacent to the high school, which is centrally located in the city and just outside the business district. The ethnicity of the student population is described in detail in Table 1. I16 is primarily Caucasian (75.2%) with approximately 52 percent of students qualifying for free or reduced lunch. Special education services are delivered to approximately 19% of students (6.7% LD/MR and 12.3% Gifted). Title One reading services are provided to 14% of students. The ELL program services approximately 11.8% of students. Approximately 10.9% of students are identified as at-risk students and are assisted through four study skills classes.

Here are some of the successes that I16 achieved during its three-year period as a NASA Explorer School:

- Increased opportunities for professional development for teachers.
- Opportunities for teachers to present to colleagues at professional conferences.
- I16 established a STEM-G Business Partnership program which supports both objectives of increasing student awareness of careers and opportunities for teacher professional development.
- I16 utilized NASA people resources, bringing Hispanic role models to excite their sub-group of Hispanic students about careers and STEM-G subjects.
- I16 has successfully leveraged their NES partnership to apply for additional grants (Pratt and Whitney Rocketdyne grant).
- I16 has increased family involvement through family science nights and home interactions.
- I16 has build career awareness into their family science nights and conducted a Career Fair to support this objective.
- I16 has increased student access to instructional computers with Internet access.

I16 entered the NES program facing two major challenges. In 2004, they had 31 percent highly qualified teachers in secondary classes teaching core subjects. They have increased that number to 70.5 percent over the duration of the NES program.

They were also looking for instructional activities to help close the achievement gaps identified by state testing between the subgroup populations of White and Hispanic students. I16 has made strides in reading, with their 8th grade gap decreasing from 51 percent to 29 percent from 2003-04 to 2004-05. However they have lost ground in math with the 8th grade gap increasing from 30 to 32 percent. There is not enough data available to report on 7th grade gaps. Tables 7 and 8 provide details on the math and reading scores for the sub-group populations.

Specifically in regard to implementing the NASA Explorer Schools program, the I16 team identified that late receipt of funds and that a lack of time were challenges for them. They also identified difficulties with turnover at the school and the field center levels. I16 also found that responding to NASA Explorer Schools opportunities, scores, or surveys in a timely manner did not always fit within the school calendar and that integrating NASA resources did not always fit with what they were required to do in their curriculum.

I16's challenges in implementing the NES program included:

- 31 percent highly qualified teachers in secondary classes teaching core subjects.
- Achievement gaps among subgroup populations.
- Notice of opportunities, scores that have to be done, or surveys completed are received that do not work within the school calendar.
- Transition of employees at Field Center Ipresented a problem with forms not being turned in on time.
- Integration of NASA resources has been somewhat challenging.
- At the school level, dysfunctional administration and/or staff; weak team; and team turnover (due to health issues of the team lead) were identified by the field center coordinator as being a challenge.

We examined schoolwide achievements at I16 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcript of a focus group interview conducted by telephone with the I16 NES team. The interview was conducted April 26, 2006. We have also used school website, NES e-Folio, survey data, and U.S. Department of Education school data to expand upon information provided in the interviews.

Outcome 1: Increased participation and professional growth of educators in science.

The faculty of I16 consists of 31 full-time teachers and 3 part-time teachers. There are two full-time administrators, one full-time and one-half time counselor, serving the school. The teachers' average years of teaching experience is 12.5 years; 62 % hold a Master's Degree and 6% have achieved degrees higher than the Master's level. Support personnel at I16 include 2 instructional aides, 1 secretary, 1 bookkeeper, 2 office aides (counselor/medication), one library aide, 6 CNP workers, and 2 custodians.

Two years into the NES program, the I16 team consists of an administrator, team lead, one math teacher, and two science teachers. Three of the original team members remain. Table 2 provides a list of the academic needs the startup team identified when first joining the NES project. During its NES participation I16 developed strategic and implementation plans that showed how it would address these academic priorities through the NES project.

The NES team and its students have participated in numerous NASA activities, including AES professional development, MSFC Leadership Symposium, national conventions (including NSTA), LARC Technology Workshop (focus on math content), and the NES Summer Orientation. They actively utilize DLN resources. Tables 3 and 4 provide a summary of the professional development opportunities and NASA resources that I16 has taken advantage of as a NASA Explorer School.

I16 NES team members made a commitment to increase the active participation and professional growth of the entire school faculty by including DLN opportunities for faculty during school hours and on teacher work days, as well as sharing opportunities to attend national conferences, and purchasing equipment (projectors and wireless computer pads) for schoolwide use.

I16 lists the need to "increase the active participation and professional growth of educators in STEM-G" as a primary performance objective. They actively address this objective by taking advantage of the professional development opportunities offered both on and off site by NES. I16 teachers took it a step further by presenting two sessions at the ASTA convention on NES/NEAT program implementation at their school. They report success in reaching out to teachers in the math and science areas, but found it more difficult to engage teachers outside of those subject areas. Overall, the team is extremely positive about how the professional development and opportunities have benefited teachers at I16.

The next section examines the extent to which the I16 school implementation of NES addresses the six guidelines for professional growth and development described below.

Guideline 1. Instructional Strategies.

- According to the I16 e-Folio, teachers, "Attended NEAT workshop at our regional field center with three students. Met with three other teachers and nine students from Missouri, Iowa, and Arkansas. We attended an abbreviated form of Advanced Space Academy with tours of the sponsoring NASA field center, rocket launching, jet plane simulations and ropes courses."

In addition to our analyses from case study, we report some key findings from the survey data on I16. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings.

- When asked how often do students in this class take part in doing hands-on/laboratory activities, two teachers responded "1-3 times per week," one responded "1-3 times per month, and one responded "sometimes" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often do students in this class take part in working in small groups to come up with joint solutions or approach to a problem or task, all four teachers who completed the survey responded "1-3 times per week" in the TLC survey.
- Here is how teachers responded to questions in the TLC survey regarding how often I16 teachers accomplish the following goals:
    - Elicit students' ideas and opinions: Two teachers responded "very often" and two responded "often".
    - Get students to justify and explain their reasoning: Three out of four teachers responded "very often". One responded "often".
    - Have students relate what they are working on to their own experience: Two out of four teachers responded "often". One responded "very often" and another responded "always".
- A total of four teachers completed the Teacher Need and Involvement survey. In responding to how much they anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, one teacher responded "a lot", one responded "some", one responded "quite a bit", and one responded "not at all".

Guideline 2. Time Intensive.

Completing the NES program, professional development opportunities have been offered at the school through a business learning network.

- Teachers report that it was difficult to get all faculty members motivated. "It's not difficult to motivate science and math teachers. In other core areas, it is somewhat difficult" (Focus Group Interview, April 24, 2006)
- The field center staff identify their support for their NES teams as "Professional development; scheduling DLN; promoting opportunities."
- Teachers attended Professional Development Training on Handheld Computers to help meet their needs assessment secondary performance objective to "increase the active participation and professional growth of educators in STEM-G."
- I16 teachers "presented two sessions at the ASTA convention on NES/NEAT programs including a PowerPoint that showcases some of the activities that we have been involved in due to our involvement with the NASA programs. This meets a needs assessment primary performance objective to 'increase the active participation and professional growth of educators in STEM-G.'"

Guideline 3. Classroom Practices.

- I16's field center staff stated that they are implementing the NES program through "Professional development. Workshop planning now has an agenda. Modeling activities. Getting STEM-G activities into schools"
- The field center staff modifies activities to be more inquiry-based. As an example, "Every time teachers do a tour, a hands-on inquiry-based lesson is provided that can be used in the classroom. Teachers also work with a professional in inquiry-based lessons to make sure they are doing it correctly. Workshops have been changed to have inquiry-based activities and by connecting the tours to the activities."
- I16 teachers "Attended NEAT workshop at MSFC with 3 students. Met with three other teachers and 9 students from MO, IA, and AR. We attended an abbreviated form of Advanced Space Academy with tours of MSFC, rocket launching, jet plane simulations and ropes courses.

Guideline 4. Content Knowledge.

I16 teachers stated that the NASA Explorer Schools program has helped them personally by providing the, "opportunity to attend science conferences obtaining countless examples and illustrations that have been used in the classroom. Learned math technology working with palms at Langley. Attendance at Leadership Symposium at Marshall and two national conventions; and attendance at technology workshop at Langley. The professional learning

experience has been very beneficial in the classroom. Teachers would like to receive more support in integrating technology in math."

- Other teachers at I16 have benefited from "shared information from conferences with other science teachers."
- According to I16's field center, "Their content workshop is rocketry and space environment because that is Field Center I's specialty. They showcase DLN."
- Aerospace educator classroom visits address the need, as defined in the I16 needs assessment to "apply and adapt a variety of appropriate strategies to solve problems; build new mathematical knowledge through problem solving; recognize and use connections among mathematical ideas; understand numbers, ways of representing numbers, relationships among numbers, and number systems; properties and changes of properties in matter; motions and forces; and how to use maps and other geographic representations , tools, and technologies to acquire, process, and report information."
- I16 has established STEM-G Business Partnerships to addresses needs as defined in their needs assessment, including "apply and adapt a variety of appropriate strategies to solve problems; build new mathematical knowledge through problem solving; recognize and use connections among mathematical ideas; understand numbers, ways of representing numbers, relationships among numbers, and number systems; motions and forces; collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom."

Guideline 5. Active Learning.

- The I16 team describes themselves as "working together as the core team through NASA Explorer Schools. New team members are working together participating in professional development experiences. Team members have participating in orientation and administrative training."
- Professional Development Training on Handheld Computers is an activity that "addresses needs as defined in the I16 needs assessment: Collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom."

Guideline 6. Coherence.

- "I16 developed their Strategic Plan based on their school needs. With the help of their 21st Century After-School Learning Center and school, they have designed and built a Mission Control Lab in an existing classroom. The lab is now fully furnished with 30 computers, including a notebook computer, projector, Smartboard, Polycom video conference system, and a high capacity laser printer. Their Strategic Plan includes the use of DLN equipment, use of the Mission Control Lab and access to notebook computers and projectors in the classroom for NES team members and other faculty. "
- "The I16 NES coordinator helped start planning during the first year. Video conference was held with NASA officials in planning family night. Representative makes frequent visits to the school. Official Learning Network representative at the regional field center worked with media team to produce a video and wrote a song and lyrics for a national video about our NASA explorer school. This was entered in a district technology competition."
- "The DLN coordinator has helped with our team with videotaping and preparing their program presented at the district meeting. Assistance has been hands-on coordination with students and teachers with important projects. Contacts have been made with the field center staff with positive response."
- Team strategies to integrate NES used by I16 include: "Working closely with team members giving assistance where needed. All teachers have enjoyed training sessions and experiences received. Overall coordination of the program starting with better administrative training."
- I16's field center gauges the school's progress toward meeting its needs based on "Teachers seeking out NASA resources, Increased awareness of NASA careers Increased knowledge about their standards"
- AES Classroom Visits address I16 needs as defined in their needs assessment to "apply and adapt a variety of appropriate strategies to solve problems; build new mathematical knowledge through problem solving; recognize and use connections among mathematical ideas; understand numbers, ways of representing numbers, relationships among numbers, and number systems; properties and changes of properties in matter; motions and forces; and how to use maps and other geographic representations , tools, and technologies to acquire, process, and report information.
- I16's NASA Family Night which consisted of a DLN and presentation, PTO meeting and Open House address the needs as defined their needs assessment to "Collaborate with peers, experts, and others using

telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom."

- The NEAT workshop at MSFC-2006 addresses needs as defined in the I16 needs assessment to "Apply and adapt a variety of appropriate strategies to solve problems; Build new mathematical knowledge through problem solving; Collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom."
- The Professional Development offered through DLN Operations addresses needs as defined in I16's needs assessment to "Collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom; Students will develop an understanding of the role of society in the development and use of technology."
- I16 applied for a Pratt and Whitney Rocketdyne grant. This addresses I16's need to "apply and adapt a variety of appropriate strategies to solve problems; build new mathematical knowledge through problem solving; recognize and use connections among mathematical ideas; understand numbers, ways of representing numbers, relationships among numbers, and number systems; properties and changes of properties in matter; motions and forces; and how to use maps and other geographic representations , tools, and technologies to acquire, process, and report information."
- I16's Career Fair addresses the needs as defined in I16's needs assessment to "Collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom' Students will develop an understanding of the role of society in the development and use of technology; How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information."
- Participation in Technology Competition addresses I16's needs to "Collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom; apply and adapt a variety of appropriate strategies to solve problems."

Outcome 2. Increased assistance for and technology use by educators in schools with high populations of underserved students.

According to their school report cards, I16's student access to instructional computers with Internet access has improved since it joined the NES program. In 2002-2003, their access ratio was 5, improving to 4.9 in 2003-2004, and reaching 4.3 in 2004-2005, which is comparable to the national ratio of 4.4. They have purchased new technologies and received professional development that has helped integrate the use of technology into their curriculum as well as serving as a vehicle for receiving additional professional development training.

The I16 team purchased the following technologies with NES funding:

- 30 computers "Resources have helped such as the new mission control computer lab where classes frequently participate."
- Notebook computer
- Projector
- SmartBoard
- Polycom video conference system
- High capacity laser printer
- Wireless computer pads
- Teachers attending the technology training for Palm handhelds were able to keep the Palms used at the training.

Examples of increasing assistance for and technology use by educators at I16 include:

- I16 made technology more accessible for students and faculty.
  I16 utilized grant funds to purchase computer technologies for students and the team.
- Planning and executing technology training sessions to assist teachers in providing instructional activities to help close the achievement gaps in subgroup populations.
- Personal professional development plans were extended to include DLN opportunities for the entire school faculty during school hours and on teacher workdays and the NES team members will expand professional collaboration through attendance at national conferences and the acquisition of projectors and wireless computer pads."
- An Official Learning Network representative at Marshall worked with the media team to produce a video and wrote a song and lyrics for a national

video about our NASA explorer school which was entered in a district technology competition.

- Teachers received professional development training on handheld computers.
- I16 established STEM-G Business Partnerships: Primary Performance Objective is to "increase the academic assistance for and technology use by educators in schools with high populations of underserved students."
- The I16 NEAT workshop at MSFC-2006 had a secondary Performance Objective is to "increase the academic assistance for and technology use by educators in schools with high populations of underserved students."
- Presentations at ASTA Convention: "Presented two sessions at the ASTA convention on NES/NEAT programs including a PowerPoint that showcases some of the activities that we have been involved in due to our involvement with the NASA programs. The secondary performance objective is to "increase the academic assistance for and technology use by educators in schools with high populations of underserved students."
- Professional Development with DLN Operations.
- A video conference was held with NASA officials in planning family night."
- "Integration of technology using videoconferencing is a school-wide approach."
- "How has the Explorer Schools program helped you personally? "Resources have helped such as the new mission control computer lab where classes frequently participate. Also learn lessons through the use of DLN."
- How does the center determine which programs to offer this school to meet its needs? "Their content workshop is rocketry and space environment because that is MSFC's specialty. They showcase DLN."
- Professional Development Training on Handheld Computers: used NASA personnel and DLN."
- NASA Family Night: "DLN & presentation; PTO meeting; Open House. Professional Development with DLN
- NEAT workshop at MSFC-2006: "Attended NEAT workshop at MSFC with 3 students. Met with three other teachers and 9 students from MO, IA, and AR. We attended an abbreviated form of Advanced Space Academy with tours of MSFC, rocket launching, jet plane simulations and ropes courses.

The NES evaluation team also incorporated some of the data from Teaching, Learning, Computing (TLC) and Teacher Need and Involvement surveys to

generate more inclusive picture of how I16 teachers integrate technology. When teachers were asked how many days a year does a typical student in the class use a computer while they are teaching their class, teachers responded only "6-10 times" a year. Teachers also responded only "1-5 times" for using NASA materials in their classroom in a year.

Outcome 3. Increased family involvement in children's learning.

I16 has encouraged family participation through family night activities and home interactions as well as working to increase family involvement in student learning. They have observed increased family participation in school events.

They have done this by:

- Involving parents and Field Center I AES and DLN in an open house/NASA night, program orientations, and additional family nights.
- Develop faculty, staff, student, and parent interest in and increase knowledge of NASA programs.
- When asked in the focus group interview if the team was able to implement the NES program school-wide, the reply was, "Special development did affect the whole school with Family Night."
- Responding to the focus group interview question, "What is your formal evaluation of the impact of your school strategic plan?" the team replied, "Observation of family participation in NASA activities (i.e., Family Night)." NASA Family Night: "DLN and presentation; PTO meeting; and Open House. I16 planned a Career Fair for which the secondary performance objective was to "increase family involvement in children's learning."

Outcome 4. Increased student interest and participation in STEM-G.

I16 identified increasing student interest and participation in STEM-G as one of the objectives in their needs assessment. They have used a variety of NASA materials and opportunities to accomplish this objective. The I16 team has identified one of the most effective strategies to increase students' interest and awareness in math and science as bringing astronauts and engineers to visit the school. They have especially recognized the effectiveness of bringing Hispanic astronauts and engineers as role models for the Hispanic sub-group of students at I16.

The following strands are indicators of what it means for students to have interest and to participate in STEM-G activities. Students who are interested and participate in STEM-G activities have the tendency to:

Participate productively in STEM-G practices and discourse

- AES Classroom Visits: Primary Performance Objective is to "increase student interest and participation in STEM-G."
- NASA Family Night: secondary performance objective is to "increase student interest and participation in STEM-G."
- NEAT workshop at MSFC-2006: "primary performance objective: increase student interest and participation in STEM-G."
- Applied for Pratt and Whitney Rocketdyne grant
- Career Fair: secondary performance objective is to increase student interest and participation in STEM-G."
- Change students from dependent to independent learners through projects and real world applications.
- Forge a connection with NASA that will help students see science and math in action through interaction with personnel and working with real data.

Noticeable curiosity in STEM-G topics and events

- In order to increase student interest and participation in science, mathematics, and technology (STEM) I16 integrated NASA materials into the curriculum and extended the use of technology schoolwide through the lab and the DLN. They also plan to extend NASA activities and knowledge to other schools in their school system.
- What has been the impact of the NES program on your students? "It has stimulated student's interest in science and math awareness from astronauts and engineers visiting the school. Students have become more inquisitive and excited."
- Professional Development Training on Handheld Computers: Secondary Performance Objective is to "increase student interest and participation in STEM-G."
- Establish STEM-G Business Partnerships: Secondary Performance Objective is to "increase student interest and participation in STEM-G."
- Professional Development with DLN Operations

Changes in self-concept

- What has been the impact of the NES program on your students?

"Hispanic role models as engineers and astronauts coming to the school and talking to the students has helped make the program more affective."

Outcome 5. Increased student knowledge about careers in STEM-G.

I16 has built career exploration into their family science night programs and through a career fair. They have invited NASA astronauts and engineers to visit campus to help the students explore STEM-G careers and learn what it takes to achieve those careers. Many of the professional development opportunities for teachers and activities for students have "increasing student knowledge about careers in STEM-G" as a performance objective. Students are given opportunities to use NASA mission data in their classes and receive exposure to STEM-G careers through inquiry-based activities and DLN activities.

The following strands indicate students' knowledge about careers in STEM-G. Students who demonstrate knowledge about careers in STEM-G also demonstrate:

Increase understanding of the enthusiastic about STEM-G careers

- In order to increase student knowledge about careers in STEM-G, I16 supported career explorations for students during school with a career fair and with families during science nights. They plan to increase the use of outside experts and collaborative tools including DLN. Students were allowed to use NASA mission data in their classes and were provided more extensive inquiry learning opportunities while using the Mission Control Lab and the DLN equipment.
- NEAT workshop at MSFC-2006: "secondary performance objective: increase student knowledge about careers in STEM-G."
- Applied for Pratt and Whitney Rocketdyne grant
- Career Fair: "primary performance objective is to increase student knowledge about careers in STEM-G."
- Participation in Technology Competition: "secondary performance objective: increase student knowledge about careers in STEM-G."
- Multiplying opportunities for students to experience integrated curriculum and to examine careers in math, science, and technology.

Outcome 6. Increased student ability to apply STEM-G concepts and skills in meaningful ways.

I16 teachers received professional development specifically targeted towards "increasing student ability to apply STEM-G concepts and skills in meaningful ways." Aerospace Education Specialists worked with students in the classrooms with activities specifically geared towards achieving this goal. In addition, I16 encouraged students to participate in a Technology Competition to demonstrate their understanding and ability to apply STEM-G concepts and skills in meaningful ways. The I16 team stated that their students consistently score at or above state and national averages on various required assessments and that I16 has consistently met AYP over the past years as an indication that this goal has been achieved. Tables 5 and 6 represent the high number of I16 students meeting or exceeding national standards in mathematics and reading standardized assessments.

Understand and use scientific explanations of the natural world in context of a problem-solving activity.

- Professional Development Training on Handheld Computers: Secondary Performance Objective is to "increase student ability to apply STEM-G concepts and skills in meaningful ways."
- AES Classroom Visits: Primary Performance Objective is to "increase student ability to apply STEM-G concepts and skills in meaningful ways.
- NEAT workshop at MSFC-2006: "secondary performance objective: increase student ability to apply STEM-G concepts and skills in meaningful ways."
- Professional Development with DLN Operations
- Applied for Pratt and Whitney Rocketdyne grant
- Participation in Technology Competition: "secondary performance objective: increase student ability to apply STEM-G concepts and skills in meaningful ways."

Evidence is available to demonstrate student performance increased in STEM-G and related subjects like language arts.

- I16 students consistently score at or above state and national averages on various required assessments. I16 has consistently met AYP over the past years.
- How does the center evaluate its own effectiveness in meeting student needs? "We absolutely do not want to get into the test score business. But, we have three schools that have said that they believe their scores have increased because of NES. The I35 principal is one that has said this. Possibly another school is I68.
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Table 1. School Demographics

	2002-2003	2003-2004	2004-2005	2005-2006
Student Population	791	519	551	
Black, non-Hispanic	15	15	13	
Asian	3	3	2	
Hispanic	131	89	96	
American Indian, Alaskan Native	0	0	0	
White, non-Hispanic	642	411	440	
School Location (rural, suburban, urban, large central city)	Small Town	Small Town	Small Town	
School Type (public, private, charter, magnet)	Public	Public	Public	
Title 1 status (yes or no)	Yes	Yes	Yes	
English Language Learners				
Free and Reduced Price Lunch	47%	47%	48%	
Teacher Population	42.5	33.5	33	

Note: Grayed-out cells indicate that data is not available as of March 14, 2007.
Source: *Common Core of Data (CCD), "Public Elementary/Secondary School Universe Survey" , 2002-03 v.1a, 2003-04 v.1a, 2004-05 (Preliminary) v.0f-preliminary*. National Center for Education Statistics (NCES). (Date not provided). Retrieved March 14, 2007, from http://nces.ed.gov/

Table 2. Summary of Academic Needs Identified by I16 in 2004

Discipline	Category	National Standard	Priority
Principles and Standards for School Mathematics	Problem Solving	Apply and adapt a variety of appropriate strategies to solve problems	1
Principles and Standards for School Mathematics	Problem Solving	Build new mathematical knowledge through problem solving	2
Principles and Standards for School Mathematics	Connections	Recognize and use connections among mathematical ideas	3
Principles and Standards for School Mathematics	Number and Operations	Understand numbers, ways of representing numbers, relationships among numbers, and number systems.	4
National Science Education Standards	Physical Science	Properties and changes of properties in matter	5
National Science Education Standards	Life Science	Organisms and environments	6
National Science Education Standards	Physical Science	Motions and Forces	7
National Educational Technology Standards		Collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom.	8
Standards for Technological Literacy	Technology and Society	Students will develop an understanding of the role of society in the development and use of technology	9
National Geography Standards	The world in spatial terms	How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.	10

Source: I16 Needs Assessment. (2004).

Table 3

NASA Professional Development Opportunities That I16 Teachers Completed

AES provide staff professional development*
Math Technology training with palms at LARC*
Leadership Symposium at MSFC*
Two national conventions*
Technology workshop at LARC*
NES Summer Orientation**
NSTA, Chicago, IL**

*Source: Spring 2006 Team Interview

**Source: Spring 2006 Team Lead Survey

Table 4

NASA (and NASA-affiliated) Resources Used

Videoconference to plan family night
MSFC staff assisted with production of a national video about I16
NES coordinator assistance with planning
DLN
Hispanic role models (engineers & astronauts)

Source: Spring 2006 Team Interview

Table 5. NES I16 Math Achievement Scores

	Year	Grade	Percent Not Meeting Standard	Percent Partially Meeting Standard	Percent Meeting Standard	Percent Exceeding Standard
School	2005	7	0	29.01	44.66	26.34
	2005	8	0	30.29	56.2	13.5
District	2005	7	0	29.01	44.66	26.34
	2005	8	0	30.29	56.2	13.5
State	2005	7	0.13	42.92	37.02	19.92
	2005	8	0.03	36.93	47.87	15.17

Source: Alabama Avenue Middle School Report Card. (2003-2006). Alabama Department of Education. Retrieved March 15, 2007, from ftp://ftp.alsde.edu/documents/ReportCards/2002-2003/101/1010010.pdf.

Table 6. NES I16 Reading Achievement Scores

Year	Grade	Percent Not Meeting Standard	Percent Partially Meeting Standard	Percent Meeting Standard	Percent Exceeding Standard
2004	8	2.81	28.39	41.95	25.85
2005	7	0.77	16.6	32.05	50.58
2005	8	1.1	25.37	38.24	35.29

Source: Alabama Avenue Middle School Report Card. (2003). Alabama Department of Education. Retrieved March 15, 2007, from ftp://ftp.alsde.edu/documents/ReportCards/2002-2003/101/1010010.pdf.

Table 7. NES I16 Comparison of Subgroup Scores in Reading on the Alabama Reading and Mathematics Test (ARMT)

Sub-Groups	2003-04 Reading Grade 7	2004-05 Reading Grade 7	2003-04 Reading Grade 8	2004-05 Reading Grade 8
All	No data	83%	68%	74%
White	No data	86%	77%	78%
Hispanic	No data	65%	26%	49%

Source: Alabama Math and Mathematics Test (ARMT) for I16. (2007). Alabama Department of Education. Retrieved April 27, 2007 from Alabama Math and Mathematics Test (ARMT).

Table 8. NES I16 Comparison of Subgroup Scores in Math on the Alabama Reading and Mathematics Test (ARMT)

Sub-Groups	2003-04 Math Grade 7	2004-05 Math Grade 7	2003-04 Math Grade 8	2004-05 Math Grade 8
All	No data	71%	No data	70%
White	No data	76%	No data	76%
Hispanic	No data	46%	No data	44%

Source: Alabama Math and Mathematics Test (ARMT) for I16. (2007). Alabama Department of Education. Retrieved April 27, 2007 from Alabama Math and Mathematics Test (ARMT).

NASA Explorer Schools Case Study Profile: J65
2004 Cohort—Rural, West Virginia Public Middle School: Grades 6-8

Summary Comments Regarding J65
J65 is a public middle school located on top of a mountain in rural West Virginia. This school was selected as a NASA Explorer School in 2004. The school enrollment was 252 students during 2003-2004 and increased to 277 with the inclusion of sixth-graders during the 2004-2005 school year. In 2004-2005 about 85 percent of students were eligible to receive a free or reduced lunch based on their family income status. All 55 counties in West Virginia are Appalachian counties. It is the second most rural state in the nation, and almost 64 percent of its population resides in rural areas. Although traditional stereotype equates rural areas with farming, no county in West Virginia relies on agriculture as its primary industry. West Virginia has continued to experience population decreases since the 1980s—especially in ages below 18 and between 18 and 27 because of the decline of the coal industry. See Table 1 for more information on the school demographics.

Here are some of the successes that J65 achieved during its three-year period as a NASA Explorer School:

- As a result of the NES partnership, J65 NES and non-NES teachers were able to attend professional development workshops and conferences. J65 teachers have found the professional development invaluable to their personal growth and careers.
- The faculty developed NASA nights and a science library for their students and parents to encourage their participation as part of larger NASA learning community.
- The innovative technologies for learning have changed how teachers teach and think about how people learn. Students are excited about hands-on activities and participated actively in science inquiry.

As a school that serves a predominantly poor population, J65 must overcome challenges that compete with STEM-G-related reform activities for teacher and administrator attention. Here are some of these challenges:

- Lack of certified science teachers has been identified as a problem area. J65 added sixth-graders to the school population, but the number of faculty members did not increase.
- Administration change has slowed the implementation process and increased the difficulty of following the NES strategic, implementation, and technology plans.
- Teachers cite lack of time as one of their biggest challenges. Teachers have difficulty finding common time to meet or sponsor any in-house professional development workshops during school time.

- Lack of support from the district officers has been identified as a challenge for J65. It has been difficult to coordinate with the district central office to convince it to allow teachers to plan NES activities during school hours.
- Implementing some of the changes involved in the NES project requires changes in school culture and community that residents in this rural community may be resistant to if viewed as change coming from outsiders. "Changing schools means changing the community and its culture. Change is not new in rural Appalachia, but the road to education reform is bumpy and curved.[1]"

We examined schoolwide achievements at J65 in terms of the extent to which the school's NES implementation fulfills the six anticipated outcomes of the NES project as outlined below. This analysis is based primarily on the transcripts of one focus group interview conducted by telephone with the J65 NES team. The interview was conducted on May 3, 2006. We have also used other resources, such as the school website, the NES e-Folio, survey data, and U.S. Department of Education school data to expand upon information provided in the interview.

Outcome 1: Increased participation and professional growth of educators in science.

The NES J65 team consists of four teachers and an administrator. The team lead is a seventh grade math teacher. The other two teachers are grades 6-8 English, math, and science teachers. One team member teaches PMI (permanently mentally impaired) students in all subjects. During its NES participation J65 developed strategic and implementation plans that entailed activities to spark and inspire students' interest in science, engineering, and mathematics. Table 2 provides a list of the academic needs the team identified when joining the NES project in 2004.

J65 identified providing opportunities for inquiry learning and increasing the use of collaborative tools and outside expertise resources as key aspects of the NES project that would benefit the school. Two technology-rich and inquiry-based activities that the J65 team and its students participated in through the NES program include First LEGO League robotics tournament competitions and e-Missions™. Tables 3 and 4 provide a summary of the professional development opportunities and NASA resources that J65 has taken advantage of as a NASA Explorer School.

[1] Hobart L. Harmon, Kenna R. Seal. (1995). Realities of Rural School Reform, *Phi Delta Kappan*, Vol. 77.

The next section examines the extent to which the J65 school implementation of NES addresses the six guidelines for professional growth and development described below:

Guideline 1. Instructional Strategies.
The J65 team members participated in NES professional development opportunities with great enthusiasm and made efforts to share what they learned with their students. The opportunities to bring STEM-G resources to the J65 school community and to take J65 students out of their community to visit STEM-G centers help immerse students in science experiences and help broaden their vision of career possibilities. Here are examples in which teachers describe the impact of NES on their teaching strategies.

- J65 students had a very enjoyable time when the mobile aerospace lab was at the school. Students were able to work on computers and were able to actually see what can be done with a computer involving space and science. They also had an opportunity to experience a flight simulator.
- "As a special education teacher, I feel like all the trips that I have been on have enabled me to come back to my classroom and share with my students, [who] probably would never travel to some of these places and see some of the things that I have seen in the last two years" (Focus Group Interview, May 3, 2006).
- "Within the last couple years we have had to incorporate/take a gear-up trip to visit a college. I have taken students to two science centers, and they have helped me to gain more knowledge of what is really out there for the kids to have hands-on experiences with" (Focus Group Interview, May 3, 2006).
- "NES has been excellent for me. I have had the opportunity to be on national TV through the NASA program. It has allowed me to enhance my technology ability. It is just overwhelming the things that it has allowed me to accomplish through this NASA program. It is awesome" (Focus Group Interview, May 3, 2006).

In addition to our analyses from the case study, we report some key findings from the survey data on J65. These data shed new light on the results of case study analyses and serve as data triangulation with our case study findings:

- When asked how often students in this class do hands-on/laboratory activities, one teacher responded "sometimes," one responded "1-3 times per month," one responded "1-3 times per week," and one responded "almost everyday" in the Teaching, Learning, and Computing (TLC) survey.
- When asked how often students in this class work in small groups to come up with joint solutions or approach to a problem or task, three teachers

responded "1-3 times per week" in the TLC survey, and one responded "1-3 times per month."

- Here is how teachers responded to questions in the TLC survey regarding how often J65 teachers accomplish the following goals:
    - Elicit students' ideas and opinions: Two teachers responded "often," while the other two responded "very often."
    - Get students to justify and explain their reasoning: Two teachers responded "always," and the other two responded "often."
    - Have students relate what they are working on to their own experience: Two teachers responded "very often," one responded "always," and one responded "often."
- When asked in the Teacher Involvement survey how much they anticipate incorporating inquiry activities into their instruction as a result of being a NASA Explorer School, one responded "some," one responded "quite a bit," and one responded "a lot."

Guideline 2. Time Intensive.

The J65 teachers have invested a lot of time in the NES professional development opportunities. They respond positively to the e-mail communications from NASA field center staff. Besides the MAEL program, we see little evidence of schoolwide integration of the program.

- "It really helped me personally, especially with meeting some very important individuals…and to go to [the NASA field] centers and see what's going on in the world. It has broadened my outlook on what's going on around me or near me" (Focus Group Interview, May 3, 2006).
- "The NASA field center staff has kept us abreast with…e-mails all the time and the weekly newsletter. We all receive that, and they really want us to do the most we can with the Explorer Schools. So we have received and corresponded with them on a weekly basis if not more than that" (Focus Group Interview, May 3, 2006).

Unfortunately, only one teacher with the J65 team completed the Teacher Involvement survey (Spring 2006). Here is a summary of this teacher's responses:

- How many NASA STEM-G activities have you used in your classroom this year? Response: none.
- How much have you participated in the following NASA activities this year?
    - Professional development: Response: 1-5 times.
    - Schoolwide events: Response: 6-15 times.
    - Use of NASA materials in your own classroom: Response: 1-5 times.
    - Shared what you learned with your colleagues: Did not answer.
    - DLN events: Response: 1-5 times.

When asked, "How much do you agree with the following?" the J65 teacher responded with the following ratings:

- The NES program has been a valuable experience for you: Response: "a lot."
- This program has been inspiring to you: Response: "a lot."
- You applied what you learned from being a part of the NES program: Response: "quite a bit."
- You integrated NASA-related materials into your curriculum: Response: "a little."
- This program has been inspiring to students: Response: "some."
- The NES program has been a valuable experience for students: Response: "some."

The Teacher Involvement survey asked, "How much have you changed in each of the following areas as a result of being in a NASA Explorer School?" Here is a summary of the J65 teacher's responses.

- Incorporate inquiry activities in your instruction? Response: "some."
- Integrate more space science into your instruction? Response: "some."
- Integrate more technology into your instruction? Response: "some."
- Integrate more geography into your instruction? Response: "a little."
- Integrate engineering into instruction? Response: "some."

The responses suggest that this teacher has gained some advantage from NASA professional development activities but is not integrating activities or teaching strategies from this professional development into the classroom learning environment.

Guideline 3. Classroom Practices.

The J65 activities reported in the NES digital portfolio are primarily out-of-school enrichment activities. The robotics team is a club activity, the career day is a special schoolwide event, and science night is an after-school program. We cannot find evidence of integration of NASA resources and expertise into the formal school learning day. We do not see evidence of how the J65 teachers are aiming their teaching strategies toward improving STEM-G instruction. As this teacher quote illustrates, we do see evidence of teachers recognizing the opportunities for integrating NES resources and materials.

- One of the NES J65 team members mentioned she has been actively contacting field center staff to get more resources or articles for her students and other teachers. The field center staff has been supportive, and the staff also e-mail and ask teachers if anything is needed.

Guideline 4. Content Knowledge.

Review of the NES digital portfolio, interview transcript, and surveys provide little evidence of increased knowledge of and skill in STEM-G content, except in a few areas like robotics where the school team was quite successful. The activity reports in the J65 digital portfolio reflect teacher enthusiasm but have limited content detail. Here are excerpts from a digital portfolio report and interview transcript.

- Two NES J65 teachers attended the summer school at NASA and learned about the latest NASA projects, visited NASA facilities, attended seminars taught by NASA researchers, engineers, and technicians, and studied topics ranging from aeronautics to interplanetary exploration. [2]
- "My experience in going to Field Center F last year was invaluable. I feel that it has increased my desire to want to do different things in the science field and to see these kids grow and to learn as much as they can about NASA opportunities. And just about knowledge in general" (Focus Group Interview, May 3, 2006).

When asked in the Teacher Involvement survey (Spring 2006), "How comfortable you are teaching concepts in the following areas?" the J65 teacher responded with the following comfort ratings (5 = a lot; 1 = not at all):

- Science: Selected "quite a bit. "
- Educational Technology: Selected "some."
- Engineering/Technology: Selected not at all."
- Mathematics: Selected "quite a bit."
- Geography: Selected "quite a bit."

These responses by the J65 teacher show that the teachers has increased his or her comfort level in teaching science, math, and geography quite a bit, and some in using educational technologies. This teacher has had more difficulty incorporating engineering education. In these cases, the isolation of the school and lack of technology-related careers in the area may play a role in making integration of engineering topics and careers more difficult. There are few engineering role models in this community.

Guideline 5. Active Learning.
J65 teachers describe how they have integrated science with reading and science in math and math in reading. They describe their participation in regular NES telecons and their students' involvement in the NES student symposium. Teachers describe their difficulties in coordinating monthly team meetings, which limits their abilities to discuss STEM-G curriculum and to plan NES implementation on a regular basis.

[2] Source retrieved April 27, 2007 from http://www.nasa.gov/centers/langley/news/releases/2004/04-046_prt.htm

- "We incorporate science with English and reading and correlate it with math activities so we still emphasize science in math activities and the reading" (Focus Group Interview, May 3, 2006).
- "We participate in the teleconference calls when all of the other Explorer Schools are calling in, and each of us has taken a turn to do that or participate in that response. We also had students attend the student symposium last year. Two students and I flew to Texas. And that was very good. The kids came back and did a PowerPoint at our science night" (Focus Group Interview, May 3, 2006).
- Teachers cite lack of time as one of their biggest challenges. Teachers have difficulty finding common time to meet or sponsor any in-house professional development workshops during school time. Teachers have tried to resolve this problem by having frequent informal face-to-face communication with each other.

When asked in the Teacher Involvement survey (Spring 2006), "How much have you changed in each of the following areas as a result of being in a NASA Explorer School?" the J65 teacher responded with the following ratings:

- STEM-G career education being integrated into the curriculum? Response: "A little."
- Students being able to apply STEM-G knowledge? Response: "a little."
- Instructional technology use for your students? Response: "quite a bit."
- Instructional technology use by you? Response: "some."
- Teacher use of inquiry? "Response: "quite a bit."
- Align instructional approaches to reflect national/state standards? Response: "quite a bit."

This teacher's responses show that the program had a positive impact on this teacher's use of technology, use of inquiry, and skills in aligning instruction with standards. Getting STEM-G career education integrated into the curriculum is still a challenge.

Guideline 6. Coherence.

The J65 team expresses a determination to sustain some of the collaborations and changes in teaching pedagogy that were stimulated through their involvement in NES. Here is how the team expresses their commitment to sustain the changes and partnerships started through NES:

- "The J65 school is hoping to have a permanent Mobile Aerospace Education Laboratory (MAEL) to be initiated by the tri-county effort of [our and the two surrounding] counties. We will provide opportunities for inquiry learning and increase the use of collaborative tools and outside expertise resources during our science night."

- Through NES funding, J65 was able to build a library and get needed resources. The field center support has been tremendous.

Summary of How J65 Meets Outcome 1.
A review of how well J65 has fulfilled the six professional development guidelines shows that teachers have tried to incorporate the hands-on and inquiry-based instructional approaches that they learned through NES experiences. The J65 teachers would benefit by having more time to integrate what they have learned into their classroom teaching and curriculum planning. Having the MAEL permanently located in the area to serve the a tri-county effort would greatly help sustain the efforts that have been started and would help address the need for more exposure to engineering education.

Outcome 2. Increased assistance for and technology use by educators in schools with high populations of underserved students.

J65 team purchased the following technologies with NES funding:

- Palm Zire 72
- Laptop
- Printer
- Projector
- Digital camera

Here are excerpts from J65 teachers that illustrate some of the technology-related teaching and collaboration goals they have identified:

- Our NASA library will provide educational resources and websites, which will be utilized by both the staff and the student body.[3]
- The middle school will have a monthly bulletin board that will provide updated information. The NASA bulletin board will be used to capture the students' attention, stimulate their thinking, and help them access their prior knowledge.3
- The middle school will collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues, and information and to develop solutions or products for audiences inside and outside the classroom.3

Technology problems and challenges did occur as reported by the J65 team:

- "There were the technology problems at the beginning of the school year" (Focus Group Interview, May 3, 2006).

[3] NASA Explorer School Digital Portfolios. Retrieved July 20, 2007, from http://aesp.nasa.okstate.edu/efolio

The technology provided for J65 through partnership with NES was designed to excite students about science and mathematics. For example, J65 participated in a cross-country flight and trip to the International Space Station as the first school in West Virginia visited by NASA's Mobile Aerospace Education Laboratory. A dozen classes were scheduled to participate in the laboratory experience. In addition, a number of community outreach programs are planned to benefit from the laboratory. The MAEL is a state-of-the-art classroom housed in a 53-foot trailer. The lab was designed to excite children in grades five and up about science and mathematics. It also houses several unique workstations that allow visitors to explore technology through "hands-on/minds-on" activities that model real world challenges in aerospace. [4]

We also incorporated some of the data from the Teaching, Learning, and Computing (TLC) and Teacher Need and Involvement surveys to generate a more inclusive picture of how J65 teachers integrate technology. When teachers were asked how many days a year a typical student in the class uses a computer while they are teaching their class, teachers responded only "6-10 times" a year. Teachers also responded only "6-15 times" for using NASA materials in their classroom in a year.

Outcome 3. Increased family involvement in childrens' learning.

"We have incorporated having NASA science nights up here since we have become a NASA explorer school. So that's showing my students what's out there, bringing speakers, and show what's really out there for them" (Focus Group Interview, May 3, 2006).

"The field center has provided things for the science night that can be distributed to the parents instead of students on that night" (Focus Group Interview, May 3, 2006).

- J65 sponsors a yearly "Family Science Night." It is open to the students and their families. The science night is used to spark children's scientific interest by allowing them to manipulate objects and participate actively. It allows them to interact with "practicing scientists." It also provides a forum for presenters to share information about careers in science. The students are able to build a connection between classroom science and the real world. Parent involvement provides an excellent opportunity for

[4] Source retrieved April 27, 2007, from http://www.nasa.gov/centers/glenn/news/pressrel/2005/05-047-Aerospace_Education.html

intellectual interaction with their children as well as increasing parents' interest and knowledge in science.
- A theme-based newsletter for families was prepared by students in the NASA Club, which included information on NASA events, astronomy events, home activities, and a calendar of school NASA-based events.

Outcome 4. Increased student interest and participation in STEM-G.

The participation in science activities and the school science fair has increased. The students have involved themselves in science projects. A J65 teacher said that at least half of the student body participated in the science fair. This is significantly more participation than what they used to have.

The following strands are indicators of what it means for students to have interest and to participate in STEM-G activities. Students who are interested and participate in STEM-G activities have the tendency to:

Participate productively in STEM-G practices and discourse.
"With the NASA team, we created a NASA club with the students, and they consist of the seventh and eighth grade students. Next year we are going to incorporate the sixth-graders with that. And that is going pretty well. The kids are interested in that. Also we have the science night each year" (Focus Group Interview, May 3, 2006).

In searching for the evidence of students' active participation in STEM-G, we found that [J65] students have competed in a LEGO robotics tournament in Wheeling, WV, in December 2006. Students learned to build and program a robot. As a result, [J65]'s LEGO Robotics team placed first out of the six "rookie" teams.[2]

Changes in self-concept.
"In NASA days students wear their NASA shirts and make them aware of what we are trying to do here" (Focus Group Interview, May 3, 2006).

Attitude changes about learning.
"We've incorporated having NASA science nights up here since we've become a NASA Explorer School. And that is showing my students out there and bringing speakers in that is what is really out there for them" (Focus Group Interview, May 3, 2006).

Active participation in hands-on and authentic scientific research.

J65 students had a very enjoyable time when the mobile aerospace lab was at the school. Students were able to work on the computers and were able to actually see what can be done with a computer involving space and science. They also were able to experience the flight simulator.

As documented in the NES e-Folio, the students will participate in hands-on experiences to explore science concepts further, define the phenomena in their own words, and discuss with other students their experiences and understandings.3

Outcome 5. Increased student knowledge about careers in STEM-G.

The following strands indicate students' knowledge about careers in STEM-G. Students who demonstrate knowledge about careers in STEM-G also demonstrate:

Changes in self-identity.
"In the space day students will sign their signatures in space. All of the students will sign on the poster and send it to space on the next shuttle" (Focus Group Interview, May 03, 2006).

Increased understanding of and enthusiasm about STEM-G careers.
In Spring 2007 [J65] eighth-graders will be participating in a Career Day. The students will be asked to dress according to the career they wish to pursue. Area dignitaries and businesspeople along with other visitors will be invited to speak to the eighth grade classrooms. This will help students understand how their current educational and personal choices will affect their future life.

Share information with peers and parents.
"We also had students attend the student symposium last year. Two students and I flew to Texas. And that was very good. The kids came back and did a PowerPoint at our science night"(Focus Group Interview, May 3, 2006).

Outcome 6. Increased student ability to apply STEM-G concepts and skills in meaningful ways.

Understand, use, and interpret the nature and development of STEM-G topics.
The J65 team reports on their participation in a state-level robotics competition and describes the award they received:

- "Our school robotics club competed in a LEGO robotics tournament in Wheeling, WV, in December of 2006. [Robotics clubs from all over the state] came together to celebrate their accomplishments and recognize

> teams for their excellence in various aspects of…robot design and performance, teamwork, sportsmanship and research. [Teams] were judged [on a competitive scoring basis.…Each] team learned to build and program a robot. The J65 LEGO robotics team placed first out of the six rookie teams."

Evidence is available to demonstrate student performance increased in STEM-G and related subjects like language arts.

J65 did not meet annual year progress (AYP) in 2004-2005 year:

- "One of [J65}'s goals and objectives is to see a difference in the science scores. And right now there is so much emphasis placed on math and English that not a lot of emphasis is placed on the science score. Although we encourage them to do their best…I think that the students being involved as a member of a Explorer School…makes them feel that they are a part of something here at school…and I think that will make them give science more of their attention when it comes to the testing" (Focus Group Interview, May 3, 2006).

Tables 5 through 7 provide J65 students' math, science, and reading scores.

Table 1. School Demographics

	2002-2003	2003-2004	2004-2005	2005-2006
Student Population	282	252	277	
Black, non-Hispanic	88	71	64	
Asian	0	0	0	
Hispanic	1	0	0	
American Indian, Alaskan Native	0	0	0	
White, non-Hispanic	193	181	213	
School Location (rural, suburban, urban, large central city)	Small Town	Small Town	Small Town	
School Type (public, private, charter, magnet)	Public	Public	Public	
Title 1 status (yes or no)	Yes	Yes	No	
English Language Learners				
Free and Reduced Price Lunch	81%	81%	85%	
Teacher Population	20	21	20	

Note: Grayed-out cells indicate that data is not available as of March 14, 2007.
Source: *Common Core of Data (CCD), "Public Elementary/Secondary School Universe Survey" , 2002-03 v.1a, 2003-04 v.1a, 2004-05 (Preliminary) v.0f-preliminary*. National Center for Education Statistics (NCES). (Date not provided). Retrieved March 14, 2007, from http://nces.ed.gov/

Table 2. Summary of Academic Needs Identified by J65 in 2004

Priority	Discipline	Category	National Standard
1	Standards for Technological Literacy	The Nature of Technology	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study
2	National Educational Technology Standards		Collaborate with peers, experts, and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom.
3	Principles and Standards for School Mathematics	Number and Operations	Understand numbers, ways of representing numbers, relationships among numbers, and number systems.
4	Principles and Standards for School Mathematics	Communication	Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
5	Principles and Standards for School Mathematics	Algebra	Represent and analyze mathematical situations and structures using algebraic symbols
6	National Geography Standards	The world in spatial terms	How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.
7	Principles and Standards for School Mathematics	Connections	Recognize and apply mathematics in contexts outside of mathematics
8	Principles and Standards for School Mathematics	Algebra	Understand patterns, relations, and functions
9	National Science Education Standards	Earth and Space Science	Structure of the Earth system
10	National Science Education Standards	Life Science	Structure and function in living systems

Source: J65 Needs Assessment. (2004).

Table 3 NASA Professional Development Opportunities That J65 Teachers Completed

NES summer orientation workshop*
Palm training*
Student symposium*
Professional development trips*
Special events**

* Source: Spring 2006 Team Interview
** Source: Fall 2005 Team Lead Survey

Table 4 NASA (and NASA-affiliated) Resources Used

Videoconferencing
e-Missions
NASA speakers
Mobile Aerospace Lab
Materials for distribution and for their library
Telecons with NES schools
First LEGO LEAGUE robotics tournaments
Plant unit
NASA curriculum
Videos
Student Signatures in Space
Plant unit

Source: Spring 2006 Team Interview

Table 5. NES J65 Reading Achievement Scores

Year	Grade	Novice	Below Mastery	Mastery	Above Mastery	Distinguished	Proficient
2004	7			48%	34%		89%
2005	7		14%	38%	31%	14%	83%
2004	8		23%	47%	19%		75%
2005	8			41%	32%		87%

Source: J65 School Report Card downloaded July 20, 2007 from the West Virginia Department of Education website at http://wvde.state.wv.us/

Table 6. NES J65 Math Achievement Scores

Year	Grade	Novice	Below Mastery	Mastery	Above Mastery	Distinguished	Proficient
2004	7			49%	29%		89%
2005	7		19%	41%	23%	14%	77%
2004	8		17%	43%	25%		76%
2005	8		16%	35%	32%	17%	84%

Source: J65 School Report Card downloaded July 20, 2007 from the West Virginia Department of Education website at http://wvde.state.wv.us/

Table 7. NES J65 Science Achievement Scores

Year	Grade	Novice	Below Mastery	Mastery	Above Mastery	Distinguished	Proficient
2004	7			37%	37%	17%	91%
2005	7		19%	48%	25%		78%
2004	8		17%	51%	27%		82%
2005	8			56%	35%		>95%

Source: J65 School Report Card downloaded July 20, 2007 from the West Virginia Department of Education website at http://wvde.state.wv.us/

NASA Explorer Schools
Case Study Schools Report Rubric
2004 Cohort

		2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
	Maximum Possible Points	**A126**	**B103**	**C103**	**D109**	**E98**	**F87**	**G DID NOT HAVE A2005 SCHOOL**	**H16**	**I16**	**J65**
TOTAL SCORE	**102**	**63**	**83**	**54**	**93**	**62**	**66**		**44**	**69**	**53**
Outcome 1: Participation and professional growth of educators in science	**48**	**34**	**43**	**31**	**45**	**41**	**39**		**26**	**32**	**28**
Guideline 1 - Instructional Strategies *[data sources*: interview transcripts; surveys: TI, Adm, TLC; e-folio]*	8	6	8	6	8	6	7		3	6	5
Guideline 2 - Time Intensive *[data sources: interview transcripts; surveys: TL, TI, FC; e-folio]*	8	6	8	6	8	8	8		4	6	4
Guideline 3 - Classroom Practices *[data sources: interview transcripts; surveys: SI, TL, TI, FC; e-folio]*	8	6	7	6	7	7	6		5	6	4
Guideline 4 - Content Knowledge *[data sources: interview transcripts; workshop reports; surveys: TL, TI, FC; Admin; e-folio]*	8	5	7	4	7	7	6		3	5	4
Guideline 5 - Active Learning *[data sources: interview transcripts; workshop reports; surveys: TI, FC; Admin; e-folio]*	8	7	6	5	7	7	6		5	3	6

NASA Explorer Schools
Case Study Schools Report Rubric
2004 Cohort

		2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
	Maximum Possible Points	**A126**	**B103**	**C103**	**D109**	**E98**	**F87**	**G DID NOT HAVE A2005 SCHOOL**	**H16**	**I16**	**J65**
TOTAL SCORE	**102**	**63**	**83**	**54**	**93**	**62**	**66**		**44**	**69**	**53**
Guideline 6 - Coherence *[data sources: interview transcripts; workshop reports; surveys: TL, TI, FC; Admin; e-folio]* *Note that negative features have to be accounted for in the weight of variables.*	8	4	7	4	8	6	6		6	6	5
Comments on Outcome 1:		1.6: It has been difficult for teachers to incoporate as many of the NASA activities…because classroom									
<u>Outcome 2:</u> Assistance for and technology use by educators in schools with high populations of underserved students	**16**	**7**	**11**	**6**	**14**	**5**	**6**		**2**	**11**	**8**
Guideline 1 - Selects, purchases, and uses technological tools with NES funding (which may be supplemented by or enhanced by other sources) [data sources: interview transcripts; technology plan; e-folio]	4	3	3	2	2	2	2		1	4	3

NASA Explorer Schools
Case Study Schools Report Rubric
2004 Cohort

		2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
	Maximum Possible Points	**A126**	**B103**	**C103**	**D109**	**E98**	**F87**	**G DID NOT HAVE A2005 SCHOOL**	**H16**	**I16**	**J65**
TOTAL SCORE	**102**	**63**	**83**	**54**	**93**	**62**	**66**		**44**	**69**	**53**
Guideline 2 - School-wide frequency of using technology tools in teaching and professional activities [data sources: interview transcripts; surveys: TL, TI, FC, TLC; e-folio]	4	2	4	3	4	2	2		1	4	3
Guideline 3 - Teachers report frequency of using the technology in STEM-G context [data sources: interview transcripts; surveys: TLC; e-folio]	4	1	1	0	4	1	1		0	1	1
Guideline 4 - Teachers report frequency of using the technological tools in preparation for teaching or other professional activities [data sources: interview transcripts; surveys: Admin, TLC; e-folio]	4	1	3	1	4	0	1		0	2	1
Comments on Outcome 2:			ISS downlink on top of schl web page								
<u>Outcome 3:</u> Family involvement in children's learning **[data sources: interview transcripts; workshop reports; surveys: SI, TL, TI, FC; Admin; e-folio]**	**10**	**3**	**9**	**4**	**10**	**3**	**7**		**5**	**6**	**6**

NASA Explorer Schools
Case Study Schools Report Rubric
2004 Cohort

		2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
	Maximum Possible Points	**A126**	**B103**	**C103**	**D109**	**E98**	**F87**	**G DID NOT HAVE A2005 SCHOOL**	**H16**	**I16**	**J65**
TOTAL SCORE	**102**	**63**	**83**	**54**	**93**	**62**	**66**		**44**	**69**	**53**
Comments on Outcome 3:		3: An administrator indicated increased attendance of parents at school activities, but	Felt that SEMA materials were juvenile. But had success in family part.			3: Gave 2 points because they are aware that family involvement is a weakness and have					
<u>Outcome 4:</u> Student interest and participation in science, technology, engineering, mathematics, and geography	**8**	**8**	**6**	**6**	**6**	**4**	**8**		**5**	**5**	**5**
Guideline 1 - Participate productively in STEM-G practices and discourse *[data sources: interview transcripts; e-folio]*	2	2	2	2	2	2	2		2	2	2
Guideline 2 -Show noticeable curiosity in STEM-G related topics and events *[data sources: interview transcripts; surveys: TL, TI, FC; e-folio]*	2	2	1	1	1	0	2		1	1	1
Guideline 3 -Change attitudes about learning *[data sources: interview transcripts; surveys: SI; e-folio]*	2	2	1	1	1	0	2		1	0	0
Guideline 4 -Actively participates in hands-on and authentic scientific research *[data sources: interview transcripts; surveys: SI; e-folio]*	2	2	2	2	2	2	2		1	2	2

		2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
	Maximum Possible Points	**A126**	**B103**	**C103**	**D109**	**E98**	**F87**	**G DID NOT HAVE A2005 SCHOOL**	**H16**	**I16**	**J65**
TOTAL SCORE	**102**	**63**	**83**	**54**	**93**	**62**	**66**		**44**	**69**	**53**
4.3: Did not take student interest survey											
<u>Outcome 5:</u> Student knowledge about careers in science, technology, engineering, mathematics, and geography	**9**	**6**	**6**	**4**	**7**	**4**	**2**		**2**	**7**	**2**
Guideline 1 - Change in self-identity *[data sources: interview transcripts; surveys: SI; e-folio]*	3	3	3	2	2	3	2		2	3	2
Guideline 2 -Increased understanding of and enthusiasm about STEM-G careers *[data sources: interview transcripts; surveys: SI, TI; e-folio]*	3	3	0	2	2	0	0		0	3	0
Guideline 3 -Share information with peers and parents *[data sources: interview transcripts; surveys: SI; e-folio]*	3	0	3	0	3	2	0		2	2	3
5.2, 5.3: Did not take student interest survey											

NASA Explorer Schools
Case Study Schools Report Rubric
2004 Cohort

		2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
	Maximum Possible Points	**A126**	**B103**	**C103**	**D109**	**E98**	**F87**	**G DID NOT HAVE A2005 SCHOOL**	**H16**	**I16**	**J65**
TOTAL SCORE	**102**	**63**	**83**	**54**	**93**	**62**	**66**		**44**	**69**	**53**
<u>Outcome 6:</u> Student ability to apply science, technology, engineering, mathematics, and geography concepts and skills in meaningful ways	**9**	**5**	**8**	**3**	**9**	**5**	**4**		**4**	**6**	**4**
Guideline 1 - Understand and use scientific explanations of the natural world *[data sources: interview transcripts; surveys: SI, TI, FC; e-folio]*	3	2	3	2	3	2	2		2	3	1
Guideline 2 - Understand, use, and interpret the nature and development of STEM-G topics *[data sources: interview transcripts; surveys: SI, TI; e-folio]*	3	2	2	1	3	2	2		2	2	3
Guideline 3 - Increased achievement in math and language arts, reading, and science standardized tests *[data sources: interview transcripts; State report card data]*	3	1	3	0	3	1	0		0	1	0
Comments on Outcome 6:						6.3: Did not meet AYP; Grade 7 math scores decreased; but grade 6 math and	6.3: AYP not reported & no great schools score				
Bonus Points: *Great School Rating* ***www.greatschools.net/***	**2**	**0**	**0**	**0**	**2**		**0**		**0**	**2**	**0**
*Definition of Data Sources											
Interview transcripts:											

NASA Explorer Schools
Case Study Schools Report Rubric
2004 Cohort

		2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
	Maximum Possible Points	**A126**	**B103**	**C103**	**D109**	**E98**	**F87**	**G DID NOT HAVE A2005 SCHOOL**	**H16**	**I16**	**J65**
TOTAL SCORE	**102**	**63**	**83**	**54**	**93**	**62**	**66**		**44**	**69**	**53**
2003 NES school teams were interviewed in the spring of 2005											
2003, 2004, and 2005 cohort case study school teams were interviewed in the spring of 2006											
Surveys:											
SI: Student Interest - taken by case study schools, spring 2006											
TL: Team Lead - taken by all NES team leaders, spring 2006											
TI: Teacher Involvement - taken schoolwide by NES and non-NES teachers at all NES schools, spring 2006											
FC: Field Center Staff - disseminated to field center education staff at all 10 NASA centers, spring 2006											
Admin: Administrator - completed by NES team administrators, spring 2006											
e-folio: An electronic portfolio for the NASA Explorer Schools project <http://aesp.nasa.okstate.edu/efolio/>											