Center for Educational Technologies®

NASA Explorer Schools Project Evaluation: Summer 2003 to Spring 2006

Final Report

September 2007

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The NASA-sponsored Classroom of the Future (COTF) program is helping to bridge the gap between America's classrooms and the expertise of NASA scientists, who have advanced the frontiers of knowledge in virtually every field of science over the last 40 years. The COTF program is administered by the Erma Ora Byrd Center for Educational Technologies® at Wheeling Jesuit University in Wheeling, WV.

The COTF serves as NASA's premier research and development program for educational technologies. In this capacity the COTF develops and conducts research on technology-based learning materials that challenge students to solve problems by using datasets and other information resources provided by the NASA mission directorates.

The authors of this report are all members of the COTF's research and evaluation team. Laurie Ruberg is associate director of the Center for Educational Technologies. Karen Chen is an educational researcher there, and Judy Huang Martin is the center's implementation research coordinator.

Recognition for these contributing authors and those who provided research assistance:

Hilarie Davis, Ed.D., president, Technology for Learning
Bruce Howard, Ed.D., Center for Educational Technologies
John Hull, Ph.D., Bethany College
Deniz Palak, Ed.D., New York Institute of Technology
Elliot Soloway, Ph.D., and Namsoo Hong, Ph.D., University of Michigan
Debbie Denise Reese, Ph.D., Center for Educational Technologies
Chuck Wood, Ph.D., Center for Educational Technologies
Tim Wright, Wheeling Jesuit University

Special thanks to members of the NASA Explorer Schools project staff and school teams for the time they put in to help us develop, review, administer, and collect the evaluation data.

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Executive Summary

Background: The NASA Explorer Schools (NES) project provides curriculum materials, professional development, and technology support for low performing, socioeconomically challenged, ethnically diverse schools serving grades 4-9. The focus of NASA's support is on improving teacher abilities and student achievement in science, technology, engineering, and mathematics.

Purpose: This report integrates the results of five previous interim reports and provides an impact analysis of the first three years of the NASA Explorer Schools intervention. This study reports the results of data collected from the start of the project in 2003 through the spring 2006.

Setting: This study includes NASA Explorer Schools participating in the program between 2003 and 2006. Schools from all 50 states plus Puerto Rico are represented in this sample group, and the intervention is carried out on a regional level through 10 participating NASA field centers located in Alabama (1), California (3), Florida (1), Maryland (1), Virginia (1), Mississippi (1), Ohio (1), and Texas (1).

Study Sample: 149 schools, 596 teachers, 149 administrators, and potentially 135,396 students were involved in this program in the 2003-2006 period that is the focus of this study.

Intervention: The NES project provides a three-year partnership between NASA and the participating schools to offer professional development, funding for technology resources, STEM-related curriculum activities, materials, and expertise, and individual consultation to help teacher and administrator teams achieve the academic goals outlined in their NES sustainability and implementation plans.

Research Method: This study examines the first three years of the NASA Explorer Schools project using a blended method approach that combines qualitative and quantitative methods. Applying a theory-based research design, a cluster-based, randomly selected sample of case study school implementations is rated and compared to the theoretical guidelines of anticipated outcomes and practices. Student achievement scores were collected to compare participating schools' standing in their district and state the year before beginning the Explorer Schools project with their standing after one, two, three, and four (one-year post completion) years of participation. The research design includes pre-/posttest comparisons to examine the impact of the STEM education intervention on school curriculum, teacher professional development, technology integration, family involvement, and student interest and achievement.

Data Analysis: The analysis uses a blended methods research design. The quantitative analysis primarily conducted on survey data includes descriptive and inferential statistics, including mixed design analysis of variance and regression modeling analysis. The qualitative data analysis followed procedures to verify interrater reliability and triangulation of data by comparing similar data questions across several instruments.

Findings: The data analysis shows that all of the 29 case study schools have achieved some level of successful outcomes associated with participation in the NES project. The cross-case qualitative analysis and regression modeling reinforce the same findings, showing that student achievement gains are most strongly associated with evidence of applying teaching instructional strategies to support inquiry, teacher reports of knowledge gains in STEM content and pedagogy, teachers collaborating to integrate NES intervention into district and/or school curriculum, and use of educational technologies to support classroom instruction. These areas should be emphasized and reinforced in future professional development for NES teachers and administrators.

Discussion: The field center implementation of the NES project was improved and made more coherent over the course of the three-year evaluation. Teachers indicated that they highly value how the NES workshops helped them grow personally and professionally. Teachers reported that they found it difficult to schedule field center staff visits to their schools, while field center staff reported facing tight timelines for providing schools with information and assistance.

Schools that met NES expectations for implementation showed positive impact on teacher growth, integration of educational technology, family involvement, and student interest and achievement in STEM-related topics and careers. While challenges faced by underachieving schools participating in NES were not erased, these schools achieved significant areas of success. The number of schools meeting their annual yearly progress goals doubled from 2003 to 2006 for all cohort groups.

The case study analysis provides detailed school-based factors that either contribute to or impede successful implementation of NES as a comprehensive STEM-related intervention. The quantitative analysis from survey data supported and in some cases further defined the trends identified in the cross-case analysis. Generally, the grounded theory model was found to be an effective tool for identifying successful school implementation. The following six areas emerged as the most critical to be further refined and expanded in future NES implementation:

- Involve students in the process of generating and evaluating scientific evidence.
- Help teachers be able to model scientific reasoning for students.
- Help teachers know how to recognize and change common student misconceptions.
- Help teachers improve their pedagogical understanding of content so that they can document the impact of specific teaching strategies on student learning.
- Help teachers work as a team to plan, review, and connect NES implementation to specific standards for student achievement.
- Prepare teachers so that they can integrate student use of technology within STEM content instruction.
- Support student participation in the scientific inquiry process.

Recommendations for Next Steps

The following recommendations were made as suggestions for next steps for the NASA Explorer School project to continue to improve and expand its comprehensive STEM-related school reform intervention program.

- Identify content and pedagogical areas for NES by narrowing the focus of what it offers schools, and offering NES services to grades K-16 partners.
- Increase the rigor of how school-based implementation is documented by implementing some restructuring to the e-Folio website and conducting an in-depth investigation on how teachers implement inquiry-based strategy and technology tools.
- Expand and improve professional development and training opportunities but target those areas that showed the strongest student achievement gains.
  - First, quality of workshops in each field center should be conducted, analyzed, and evaluated.
  - Second, technical skills and teaching strategies have the greatest impact on constructivist uses of technology; workshops should focus on increasing teachers' technical skills and knowledge about constructivist teaching strategies.
- Research designs for future evaluation should include a randomized controlled trial study design as well as continued and expanded case study research that was begun in the three-year period reported here.

1. Background and Purpose

"The United States faces a critical shortage of highly qualified mathematics and science teachers" (NCES, 2005). This deficit will have a huge impact on the need for highly skilled technical workers that NASA and other science and technical industries and enterprises face now and in the immediate future. Members of the U.S. Education and Labor Committee recently proposed renewing the No Child Left Behind (NCLB) legislation with changes to help more students reach proficiency in math and reading to close the achievement gap. Several features of the revised NCLB proposal stand in parallel to the NASA Explorer Schools three-year partnership program with grades 4-9 schools. These features include equal and flexible science, technology, engineering, or mathematics (STEM) enhancement opportunities for schools, a rich and challenging curriculum, support for teachers and principals, school accountability, and steps to turn around low-performing middle and high schools with focused and sustained professional development support.

The U.S. deficit in science and mathematics graduates prepared to pursue technical careers has been documented and discussed since the 1980s. Why hasn't this problem been solved by previous science education initiatives? What do we know about K-12 science and mathematics reform initiatives that can help solve this national crisis?

The Center for Educational Technologies® (CET) at Wheeling Jesuit University in Wheeling, WV, which houses the NASA-sponsored Classroom of the Future (COTF) program, has served as the lead evaluator for the NASA Explorer Schools (NES) project since the inception of the program. The purpose of this section is to place the CET evaluation activities into appropriate perspective with regard to the startup of the NES project, its goals and objectives, and the role that the project evaluation would play in helping to inform NES project management about the implementation and effectiveness of project activities.

Critical Events That Impacted NES Implementation

During the three years of this evaluation, the NASA Explorer Schools project faced changes within NASA and across field centers, new policies enacted by Congress and implemented by other federal agencies, and several natural disasters (see Table 1.01 for a complete list of critical events). Leadership changes spanned NASA headquarters' top administrator, field center staff, and the Center for Educational Technologies, the host organization for the evaluation. In addition, NASA education proffered a new vision, which is currently expressed by the NASA education framework[1]. It encompasses the breadth of science and engineering topics addressed by NASA space missions and research. However, it also considers vertical coherence for learners of all ages, from kindergarten through graduate school, and it ultimately works toward employment in a STEM-related area.

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[1] Information about the NASA Education Strategic Coordination Framework is available online at http://education.nasa.gov/about/strategy/

In the surveys completed by teachers and administrators and in focus group interviews, NES team members frequently discussed the impact of No Child Left Behind Legislation on school instructional practices and teacher choices. Their most frequent comment addressed science assessment. Since it was not required by most states, teachers said they were being asked (or required) to focus their lessons more narrowly on language arts, reading, writing, and mathematics. In the 2007-2008 school year science assessment is required, a change that will help many NES teachers who had to squeeze in NASA activities and inquiry activities or in some cases ended up pushing science out of the classroom altogether.

On Feb. 1, 2003, NASA's space shuttle Columbia broke apart while returning to Earth from a 16-day science mission in orbit. This accident impacted the NES project through the resulting delays and in some cases elimination of shuttle launches and changes in shuttle and space station education activities.

In the summer and early fall of 2004 and 2005, NASA field centers and schools were temporarily closed because of hurricane damage. The storms devastated not only school and field center facilities, but ravaged the infrastructure of the communities and directly touched the lives of NES personnel and participants alike.

Personnel turnover, flooding, fires, tornados, and district, state, and federal mandates regarding teacher certification and curriculum requirements affect schools all the time. The fact that the NASA Explorer Schools project represents a three-year partnership between NASA and a school makes these social, political, and nature-related incidents much more noticeable. As the case study reports show, schools respond to crises differently depending on the extent of the damage, the resources available to mediate the damages, and the response of the staff and community affected. Similarly, NASA Explorer Schools' responses to the opportunities made available through the NES partnership varied widely.

Table 1.01. Critical Events 2003-2006

	Center for Educational Technologies (CET)	NASA/NES
2003	Submitted NES project for Institutional Review Board approval.	New leadership at KSC, MSFC, SSC, and GRC.
	A hybrid evaluation design was adopted and combined with a scientific-based research (SBR) methodology to compare a given implementation year to a comparison group to measure the effect of the program for a given year.	Columbia shuttle disaster.
	Brief 1: NES program and the evaluation framework.	
2004	Developed a logic model of program supports.	NASA associate administrator resigns, and many staff changes occur at DFRC, JSC, and LARC.
	CET/NES Evaluation Advisory Committee is established to review and identify measures for each of the six program objectives.	Education Advisory Committee. NASA transformation structure released. NES goes international. Hurricane Francis closes KSC. Hurricane Ivan. Each field center will develop an action plan for how it will organize center resources and personnel to meet each of the six objectives.
	CET selects new director, new NES evaluation lead, and new evaluation team members.	
	Brief 2: Evidence from 2003 workshops. Brief 3: Findings from Year 1. Strategic and implementation plans analysis.	
2005	Developed a logic model of the evaluation process.	Change in leadership at NASA is followed by a series of resignations and new appointments. New leadership at JSC, LARC, SSC, and GRC
	One school was selected from each of 10 field centers. DFRC did not have a school in the 2004 cohort, thus only 29 schools were selected for case study.	Hurricane Wilma closes KSC. Hurricane Katrina closes SSC. Hurricane Rita closes JSC and SSC.
	Interim CET directors, three departing team members, changes in evaluation leadership, new evaluation team members.	In fiscal year 2006 the federal government supported across 13 departments and agencies 105 programs that focused on kindergarten through postgraduate STEM education, with an expenditure of $3.12 billion. Deficit Reduction Act called for the establishment of an Academic Competitiveness Council (ACC), comprising federal officials with responsibility for STEM education programs and chaired by the Secretary of Education. The council was charged with identifying and reviewing all federal STEM education programs and their target populations, assessing their effectiveness, identifying areas of duplication, and making recommendations for greater integration and coordination.
	Challenge report. Digital Learning Network report. NES-handheld user community report. Student content assessment report.	
2006	New CET director (Wood), two departing evaluation team members (Palak, Davis-contract ended), one new team member (Chen).	NES leadership changes and program moves from NASA headquarters to GRC. Leadership changes at ARC and LARC.
	Brief 4: Evidence that the model is working. Brief 5: Integration and coherence. Family needs assessment report. Mission: Fuel your imagination!	President announced fiscal year 2007 budget request, which includes a $16.8 billion for NASA, a 3.2 percent increase over the 2006 budget.
2007	Developed rubric to score 29 case study schools.	After yearlong effort, ACC released findings on May 10.
	29 case study report. NES final report.	

This report presents the results of a three-year analysis of the design and implementation of the NES project. It summarizes the impact NES has had on participating schools, teachers, students, and their families. The evaluation is designed to test the grounded theory guiding NES, which proposes that effective teacher professional development in science education includes assistance for technology integration by educators at underserved schools and that family involvement in student learning will lead to increases in student interest in STEM topics and careers as well as increases in student abilities to apply STEM concepts and skills in meaningful ways. The findings reported here summarize the evidence collected during the first three years of the program to demonstrate ***increased:***

1. Participation and professional growth of educators in science.
2. Assistance for and technology use by educators in schools with high populations of underserved students.
3. Family involvement in children's learning.
4. Student interest and participation in science, technology, engineering, and mathematics.
5. Student knowledge about careers in science, technology, engineering, and mathematics.
6. Student ability to apply science, technology, engineering, and mathematics concepts and skills in meaningful ways.

Previous Evaluation Reports

Brief 1 (McGee, Hernandez, & Kirby, 2003) established that the NES program had identified and engaged underserved schools, teachers, and students with a comprehensive portfolio of curriculum and professional development supports.

Brief 2 (Hernandez, McLaughlin, Kirby, Reese, & Martin, 2004) evaluated the summer 2003 workshops and found participants were very positive about the professional development experience they had. Brief 2 recommended the NES professional development focus on:
- School content priorities.
- A balance of content, active learning. and reflection in professional development.
- Approved curriculum resources.
- Family involvement and career education strategies.
- Aligning follow-up support with the strategic and implementation plans.
- Using evaluation data to make program decisions.

Brief 3 (Hernandez, McGee, Reese, Kirby, & Martin, 2004) reviewed the implementation and results from the first year of implementation and offered lessons for improving the coherence and design decisions in terms of team organization, participation, and professional development supports.

Brief 4 (Davis. Palak, Martin, & Ruberg, 2006) introduced a logic model for the evaluation plan that outlined the key areas of impact and how they will be evaluated as well as the data sources. It described how the NES logic model is implemented within the mixed method approach. We summarized findings and made recommendations for the next steps for the program and its evaluation. The findings were organized within the context of the four major hypotheses of the NES model:

1. How does the NES program encourage more involvement with NASA programs, products, and services?
2. How does the NES program involvement increase teacher competence?
3. How does NES program involvement increase family involvement?
4. How does NES program involvement increase student interest, attitude, and achievement in STEM-G?

Brief 5 (Ruberg, Martin, & Chen, 2006) represented a summary of findings of the data collected from the 2005-2006 academic year—the third year of the NES program. The discussion section of this report and the attached appendices documented successes and challenges that NES experienced in its third year. The data collection and analysis addressed the anticipated outcomes of the program: increased growth of educators in science, assistance for technology use by educators serving underserved and/or ethnically diverse students, family involvement in student learning, and student interest, participation, knowledge, and abilities in STEM topics and careers.

This final report integrates previous findings with additional data in order to present an overall assessment of the extent to which the project has been successful in achieving its anticipated outcomes. The review of literature in the next section provides background for refinement of these questions and articulates the theoretical framework that guides this evaluation as to how closely the project adheres to the research-based guidelines. The methods section describes the sample group, data collection sources, and processes, and it defines the intervention and how it was carried out by regional centers and implemented by schools. Finally, the methods section describes how the qualitative and quantitative methods were blended together in the theory-based evaluation framework to determine what impact the NES program has had on participating schools, administrators, teachers, students, and families.

This study is relevant to those educators and policymakers who are examining school reform initiatives designed to improve science, technology, engineering, and mathematics education projects. The findings from this study will be particularly useful to scientists and educators affiliated with NASA who are looking for ways to build on the interest that students have in space science and exploration with classroom teaching tools and resources that will help teachers increase student learning in STEM disciplines.

2. Theoretical Framework

The NASA Explorer Schools Model: A Theory-based Evaluation

The NES project was designed to create a pre-college, formal education mathematics and science initiative that would inspire and prepare youth to pursue science and technology careers. As a grades 4-9 intervention, NES was to address the goals outlined in Figure 2.01 as well as the following criteria: reach out to younger students, partner with others and extend collaborations, engage minority and underrepresented students, and weave together opportunities and materials from across NASA. As Figure 2.01 shows, the program goals are redefined as a set of theoretical constructs that guide the NES project interventions, presented by NASA field center educators and carried out by school administrators, teachers, families, and students.

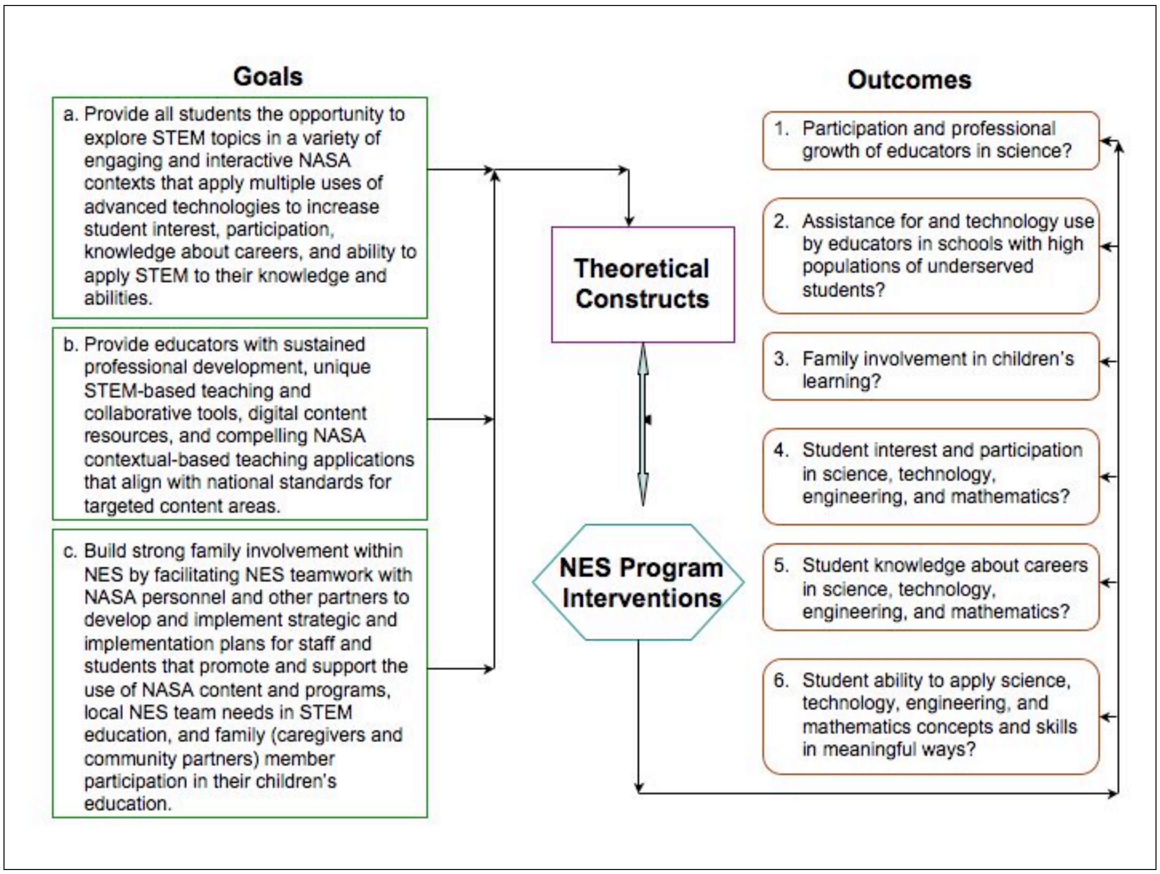

Figure 2.01. This diagram illustrates the relationship between NASA Explorer Schools project goals to a set of theoretical constructs that guide program interventions to reach the six anticipated outcomes.

During the first two years of the project, the evaluation team provided process evaluation services to the NES management team to verify that the services and resources being offered were being delivered as intended to the desired target populations. Brief 4 (Davis, Palak, Martin, & Ruberg, 2006) described how field center staff worked with the first cohort of schools during 2003-2004, from planning the summer orientation workshops to providing onsite support during the school year. At the end of that first year (summer

2004), with 50 new schools coming on board, the field centers and NES headquarters decided to hire coordinators specifically for the program. Their role was defined as the main point of contact for the school at the field center for questions, services, and support. The aerospace education specialists (AES) continued to provide onsite support. The NES coordinators come from STEM backgrounds in K-12 education so they are able to help the school teams implement the program, advising them on strategies and ideas for accomplishing their goals. In fall 2005 five Digital Learning Network coordinators were added to the field center teams to support the NES schools' use of this resource.

In January 2006 the NASA field center staff (AES, NES coordinators, and Digital Learning Network coordinators) who were responsible for implementing the program gathered for a 2½-day "evaluation summit" to review the evaluation data collected thus far and to create guidelines for making continued program implementation more coherent and consistent in services and support strategies. Areas of consensus regarding successful NES implementation strategies that emerged from the summit meeting are summarized in Brief 5 (Ruberg, Martin, & Chen, 2007). Figure 2.02 below highlights implementation strategies most likely to lead to the desired outcomes for the four sequential phases of the intervention process.

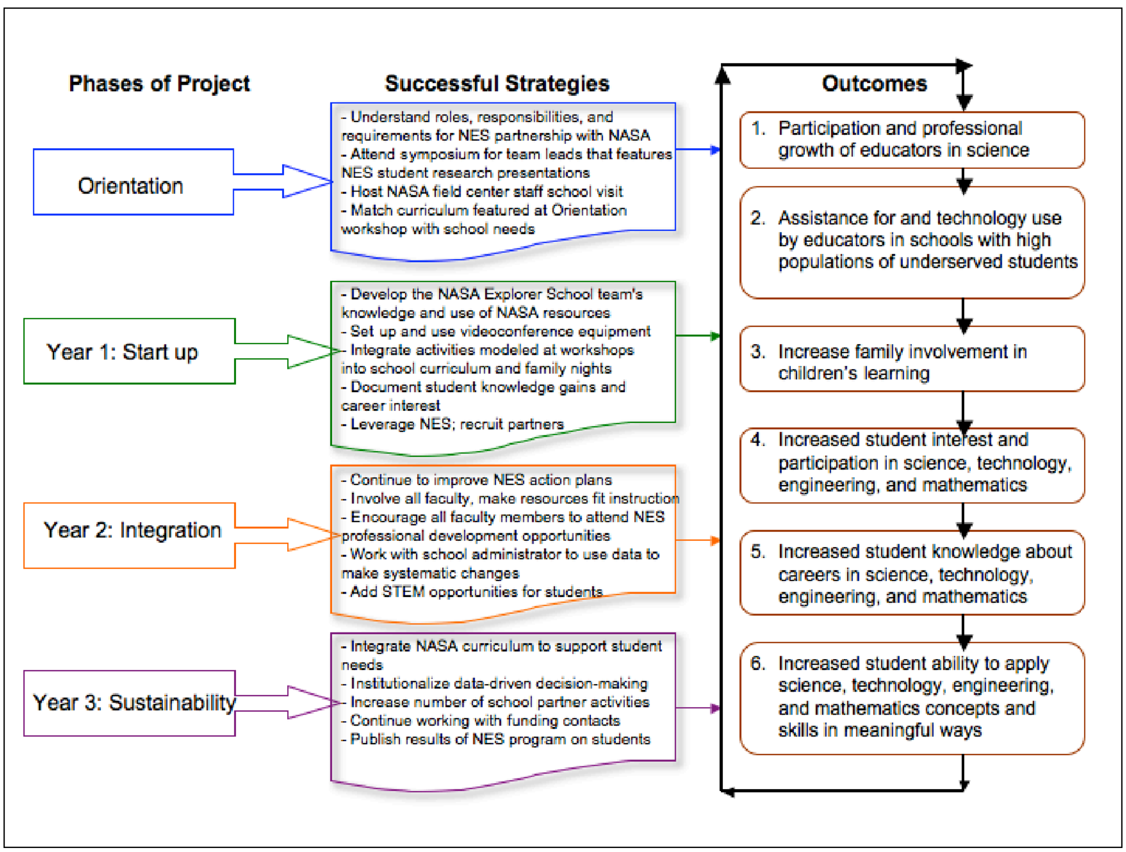

Figure 2.02. This flowchart provides an overview of the four sequential phases of the NES intervention with highlights of successful strategies that schools should follow and that NASA field center educators should support in order to achieve the six desired outcomes.

The assumptions investigated in this evaluation include (1) How closely does the implementation of NES match the theoretical constructs for successful achievement of program goals? and (2) To what extent do the participating NASA Explorer Schools provide evidence of achieving the anticipated outcomes of the intervention?

NES Implementation Strategy

This section describes how the field centers are working with the schools, from orientation workshops to summer content workshops to sustainability workshops.

Orientation workshops. The NES coordinators work with field center staff to plan the orientation workshops. The design process takes place throughout the spring and is based on an assessment of the previous year's agenda, the needs of the schools, and the expectations and changes recommended by NES leadership. The planning process is collaborative within the field center because local resources are used. The aerospace education specialists provide workshops and act as facilitators so they get to know the teams they will be working with throughout the year.

Content workshops. In the second year of the program, NES team members or other teachers from their schools can attend a content workshop outside of their region. They choose the workshop based on their interests, teaching assignments, and students' needs.

Sustainability workshops. To support the NASA Explorer Schools after their initial three-year involvement with the program, NES headquarters organized sustainability workshops and support for schools in their third year of participation and beyond. After three years a school moves into a sustainability program of support managed by the National Alliance of State Science and Mathematics Coalitions (NASSMC). The Partnerships for Sustainability program is based on a system where proposals are solicited from state-based coalitions of business, education, and state government who have entered into a partnership with established NASA Explorer Schools in the state. The partnership must make a commitment to the implementation of an action plan to strengthen and sustain the individual NASA Explorer Schools and to improve STEM education statewide.

Teacher Professional Development and Its Relationship to Student Achievement

Three of the themes that were used in the planning and assessment of the NASA Explorer Schools 2006 orientation and summer professional development workshops for teachers were based on research by Garet et al. (2001). These three aspects of teacher professional development are (a) focusing on science, technology, engineering, mathematics, and geography content; (b) fostering coherence in professional development so that reform initiatives are connected with other activities at the school; and (c) promoting active learning.

In the analysis presented in this report, we will show the connections between professional development for teachers and student science achievement. We identified six relevant guidelines for teacher professional development that focused on science education from the educational research literature. We also looked for guidelines from research most closely related to the NES project in terms of STEM-related content focus, use of inquiry teaching strategies, a breadth of implementation that was national in scope, and intentional selection of high ethnic, low socioeconomic population schools.

The six guidelines for effective teacher professional development combine evidence of how to link improvements in teaching practices that lead to improvements in student science achievement (Craig, 2006; Windschitl & Thompson, 2006; Supovitz & Turner, 2000; Committee on Science Learning Kindergarten through Eighth Grade, 2007) to models of student learning and instruction that research suggests are most effective for teaching students science proficiency. While one model emphasizes how to improve the instruction, the other focuses more on the processes of learning.

The following six guidelines combine these two approaches into an integrated summary of teaching and learning goals. These guidelines reflect what current research suggests are best practices for effective instruction that promotes science proficiency. These criteria are also useful for relating NES interventions to current research and integrating the anticipated outcomes of NES into a coherent framework. To emphasize the continuity between these guidelines and evaluation instruments, the guidelines are categorized according to the NES professional development themes focusing on content, fostering coherence, and promoting active learning. Here are the six guidelines for professional development that foster student achievement in science:

1. *Instructional Strategies*. Participants are immersed in inquiry, questioning, and experimentation, and thereby model inquiry forms of teaching. Programs that model scientific reasoning have a greater influence on student achievement than programs that train teachers to use specific curricula (Bybee, 1997). The professional development experience incorporates models of instruction that address (or combine) these four aspects of science proficiency (Committee on Science Learning Kindergarten Through Eighth Grade, 2007; Lubienski & Lubienski, 2006) so that students:

   a. Know, use, and interpret scientific explanations of the natural world.
   b. Generate and evaluate scientific evidence and explanations.
   c. Understand the nature and development of scientific knowledge.
   d. Participate productively in scientific practices and discourse.

2. *Time Intensive*. The professional development is intensive and sustained (Smylie, Bilcer, Greenberg, & Harris, 1998). This category reviews the workshops that teachers and administrators attended and the peer training and sharing teachers did with their colleagues after the workshop.

3. *Classroom Practices*. The professional development engages teachers in concrete teaching tasks based on the teachers' experiences with students (Darling-Hammond & McLaughlin, 1995; Lee & Bowen, 2006; Miller & Rowan, 2006).

4. *Content Knowledge*. Professional development must focus on subject matter knowledge and deepen teachers' content skills (Cohen & Hill, 1998). More specifically, "programs that focus on subject matter knowledge and on student learning of particular subject matter are likely to have larger positive effects on student learning than are programs that focus on teaching behaviors" (Kennedy, 1998, p. 591). This would include discussions of common student misconceptions and how to engage students in correcting these preexisting ideas.

5. *Active Learning*. The professional development should be grounded in a common set of standards and must show teachers how to connect their work to specific standards for student performance (National Research Council, 1996; National Council for Geography Education, 2005). Common high standards are strongly related to achievement (Third International Mathematics and Science Study).

6. *Coherence*. Reform strategies must be connected to other aspects of school improvements, such as seeking partnerships and collaborations to leverage the NES funding with other dollars and looking for other ways to sustain the NES initiatives (Supovitz & Turner, 2000; Supovitz, Mayer, & Kahle, 2000; Garet et al., 2001).

Assistance for and Technology Use by Educators

One of the important NES outcomes for the schools is to provide technology support and encourage the use of technology in teaching and learning. The majority of accomplishments in science are often achieved by sophisticated applications of technology. Technology is a promising tool for learning science content and processes (American Association for the Advancement of Science, 1993). The use of technology in teaching should be not only for the purpose of teaching about technology, but for enhancing teaching and learning with technology. As outlined by Flick and Bell (2000) and Garofalo et al. (2000), the following five components of effective integration of technology in teaching and learning STEM offer guidance in linking improvements in the use of technology to prepare science teachers with the training provided by NES:

1. Teachers introduce technology in the context of science content.
2. Teachers use appropriate pedagogy to incorporate technology.
3. Teachers take advantage of the unique features of technology during the instruction.
4. Teachers make scientific views more accessible by using technology.
5. Teachers incorporate multiple representations using technology.

Technology integration is one of the major concentrations of NES professional development for teachers. Literature has indicated that technical skill and constructivist teaching occur simultaneously to influence technology integration. The combination of technical skill and constructivist teaching also relates to the development of a constructivist philosophy. Positive attitude toward technology integration also stood out as an important component of technology integration. The NES workshops are designed to improve teachers' STEM teaching strategies, use of technology in their classroom, and their own technical skills in order to promote effective technology integration.

Family Involvement in STEM Areas

Broadly defined in the education literature, parent involvement refers to parent participation in one or more school-related activities (e.g., attending a parent-teacher conference, volunteering at school, helping with homework, encouraging student achievement). Parent participation in student learning can foster reinforcement of student learning and enhance the relationships between the educational system and families (McDermott, Goldman, & Varenne, 1984). Moreover, parents with different demographic characteristics can exhibit different types of involvement, and the types of involvement exhibited by parents from dominant groups had the strongest association with achievement (Lee & Bowen, 2006).

The NASA Explorer Schools project's explicit encouragement to involve families in school-related activities such as family nights, star nights, and the lunar challenge has been an important strategy for improving STEM education. However, faced with the ongoing task of involving families, teachers often struggle with the reality of inconsistent participation (Epstein & Connors, 1995). Previous research warned that the impact of family involvement did not associate with higher levels of student achievement unless it was sustained over time (Balli, Wedman, & Demo, 1997). This implies that good practice of family involvement should operationalize and explore the quality of involvement (Bradley, Caldwell, & Rock, 1988).

Students' Interest and Participation in STEM

An early notable contribution toward science attitude was made by Gardner (1975), who classified it as a complex mixture of the longing to know and understand, a questioning approach to all statements, a search for data and their meaning, a demand for verification, a respect for logic, a consideration of premises, and a consideration of consequences. In essence, there are features that might be said to characterize scientific thinking and are cognitive in nature. Science attitude positively relates to interest in science (Pell & Jarvis, 2001). Several studies have indicated differences in students' interest in and attitudes toward science, particularly during the primary to secondary transition years (Ferguson & Fraser, 1999; Martin et al., 1999). In Australia students have shown that interest in and attitudes toward science decline as they progress from primary to secondary school (Goodrum, Hackling, & Rennie, 2001). In this study we sought to examine students' interest and participation in STEM activities as a result of NES.

Students' Knowledge About Careers in STEM

Intervention studies on promoting math and science career awareness have been undertaken for years and have shown that interventions with minorities and girls must begin early to influence their career aspirations effectively (Haussler & Hoffmann, 2002;

Holland, 1997). It would be too late for students to change old patterns and remediate math and science skills by the time they reach the ninth grade. Previous research has shown that among students who graduated with baccalaureate degrees from four-year colleges, those who expected as eighth-graders to have science-related careers at age 30 were 1.9 times more likely to earn a life science baccalaureate degree than those who did not expect a science-related career. Students with expectations for a science-related career were 3.4 times more likely to earn physical science and engineering degrees than students without similar expectations (Tai, Liu, Maltese, & Fan, 2006).

Fouad (1995) designed a one-year intervention to improve minority students' awareness of and preparation for math and science careers. The intervention included a large group field trip, invited speakers, and career shadowing. Fouad found that students' occupational knowledge and their achievement and effort in math and science increase as a result of increasing their awareness for math and science careers (Fouad, 1995). The NES project is also unique in that the schools are selected on a competitive basis, and priority is given to minority serving, economically challenged, and underachieving schools. In this study we report the findings on how the project has impacted students' interest and understanding of STEM careers.

Students' Ability to Apply STEM Concepts and Skills in Meaningful Ways

There has been prolonged discussion and research on providing hands-on STEM activities using everyday materials. The learning becomes meaningful when students relate concepts to their lives and to real life (Palmer, 2004). The importance of meaningfulness to learning can never be overemphasized. Numerous researchers have also indicated that knowing, learning, and cognition are social constructs, expressed in actions of people interacting within communities (Clancey, 1997; Lave, 1991; Wilson & Myers, 2000). Likewise, when students encounter everyday representations, such as thermometers, they can connect familiar ideas to complex science.

A Theory-based Rubric to Guide Case Study Reports and Cross-case Analysis

The guidelines summarized from this review of the professional development, value-added assessment, effective family involvement strategies, and student interest/achievement research in STEM-related areas was organized into the NASA Explorer Schools Rubric: Measuring School Success in Achieving the Six Anticipated Outcomes (included as Appendix 1 to this report). The rubric serves as a summary scoresheet that the evaluation team used to assess how closely the stratified randomly selected case study schools fit the theoretical model. The rubric guidelines and categories of review correspond directly to the grounded theory model presented in this section. As use of the rubric led to areas where interpretation of guidelines and ratings were inconsistent, the rubric was revised to include greater detail from the research literature and formative evaluation recommendations as presented in Figure 2.02. This process is consistent with the guidelines for theory-based evaluation recently discussed by the Committee on Science Learning Through Eighth Grade (2007), Datta (2007), Graue, Hatch, Rao, and Oen, (2007), Harlen (2007), Leviton (2007), and Lipsey (2007).

Refinement of Evaluation Research Questions

Below is a list of questions that emerged from the theory-based framework that will be addressed in the findings and discussion section.

How was the NES project evaluated from the NASA field center, school, teacher, and student perspective?
- How was the NES intervention evaluated?
- How were the field centers evaluated?

How was the NES intervention implemented?
- How closely did school-level implementation align with the theoretical model?
    a. What were the areas where school-level implementations fell short of the model?
    b. What were the areas where school implementations (that have at least met program expectations) met theoretical criteria?
- How frequently was the school-based implementation successfully completed?
- How unique was each case study implementation?
- What were the cross-cutting themes evidenced by highly successful schools?
- What were the cross-cutting themes evidenced by the least successful schools?
- How were the level, frequency, and method of delivering NASA support associated with school success in successfully implementing the NES project?

How effective was the grounded theory model as a predictor of NES school success?
- How was a rubric rating of school success associated with each of the six anticipated outcomes for the NES project?

What impact has participation in the NES project had on teacher use, attitudes toward, and integration of technology by teachers?
- Did the NES teachers change in terms of their technology use, attitude toward changes, and technology skills?

What evidence has the evaluation collected regarding goals for student interest and achievement?
- Did the NES project increase students' interest and participation in the STEM-related subjects?
- Did the NES project increase students' interest, awareness, and knowledge about careers in STEM-related areas?
- Did the NES project increase students' ability and skills to apply STEM-related concepts and skills in meaningful ways?

3. Research Methods

Setting and Context of Study

The evaluation examines the NASA Explorer Schools project from its inception in 2003 through spring 2006. Three cohorts of 50 schools selected in 2003, 2004, and 2005 were studied, but only the 2003 cohort completed its three-year project commitment during the time span of this study. School, teacher, and student data of the three cohort groups were collected beyond the spring of 2006 as part of the research design. Schools from all 50 states plus Puerto Rico were represented in the combined sample group. The NASA Explorer Schools program was managed at NASA headquarters in Washington, DC, until fall 2006 when project management was moved to NASA's Glenn Research Center in Cleveland. The intervention was carried out on a regional level through 10 participating NASA field centers located in Alabama (1), California (3), Florida (1), Maryland (1), Virginia (1), Mississippi (1), Ohio (1), and Texas (1).

The first three years of the NES intervention being investigated here include program refinement, adjustments, and restructuring based on formative evaluation findings and recommendations as well as direct input from the field center coordinators and school teams. Significant changes to the intervention components, training strategies, and school selection processes will be described in the context of how these changes impacted data collection, analysis, and interpretation procedures.

Sample Selection

A total of 149[2] schools, 596 teachers, and 149 administrators serving a population of 135,396 students were accepted for and targeted for this science education intervention project during the three-year period of 2003-2006 that is the focus of this study. A key feature of the NASA Explorer Schools project was its conception as a way to serve underperforming schools that were in greatest need of STEM professional development support, curriculum and technology resources, and increased opportunities for student engagement in STEM topics and careers. Table 3.01 shows the minority distribution in NES schools by region.

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[2] As explained earlier, between 2003 and 2006, 50 schools were selected per year as NASA Explorer Schools. One of the 50 schools from 2004 closed and was not replaced, so the 2004 cohort has 49 participating schools.

Table 3.01. Minority Enrollment in NES Schools by Region

	Hispanic	*Black*	*White*	*Other*
National Total	19%	16%	57%	8%
NES Total	26%	29%	37%	8%
National Northeast	14%	15%	64%	7%
NES Northeast	21%	25%	49%	5%
National Midwest	7%	14%	74%	5%
NES Midwest	9%	36%	38%	17%
National South	17%	24%	54%	5%
NES South	20%	39%	37%	4%
National West	39%	6%	43%	12%
NES West	45%	10%	32%	13%

Percentage distribution of race/ethnicity of public school students enrolled in kindergarten through 12th grade, by region, fall 2004.

Table 3.02 shows the aggregate number of teachers and students served by the NASA Explorer Schools program by cohort year.

Table 3.02. Summary of NASA Explorer Schools Population Demographics

Cohort Year	***Number of NES Teams***	***Number of NES Schools***	***% of Schools Considered High Poverty***	***% of Schools Considered High Minority***	***Number of Students Served***	***Number of Teachers Served***
2003	49	61	76	76	34,976	1,409
2004	50	67	82	75	44,707	1,801
2005	50	57	98	82	42,066	2,015

Table 3.03 shows demographic distributions of NES team members.

Table 3.03. Demographics for NASA Explorer School Teams

Gender		
Male		437
Female		1281
Nothing Selected		285
Nationality		
U.S. Citizen		1649
Not U.S. Citizen		13
Nothing Selected		341
Individual with Disabilities		
Yes		35
No		1528
Nothing Selected		434
Ethnicity		
Black or African-American (Non-Hispanic)		255
Asian		42
White (Non-Hispanic)		1194
Hispanic/Latino(a)		83
American Indian or Alaska Native (Non-Hispanic)		48
Native Hawaiian or Pacific Islander		8
Other		19
Nothing Selected		374
About how many students do you teach this each year (August through July)?		
Total		200525
Average		
No Answer		537
Have you particpated in other NASA-sponsored education or research programs?		
Yes		583
No		1089
Nothing Selected		331
If yes, how many?		
Total		41073
Average		
No Answer		1460
Number of Participant Reports Entered		2003

Table 3.04 shows the demographic comparison of all NES schools with our randomly selected case study schools.

Table 3.04. Comparison of Case Study Schools with All 2003, 2004, and 2005 NASA Explorer Schools

Demographic Information

(ALL NES SCHOOLS)

	2003	2004	2005
School Locations			
Rural	35%	34%	24%
Suburban	21%	14%	20%
Urban	37%	52%	56%
School Characteristics			
Title I	74%	76%	88%
Low SES student population	63%	61%	62%
Overall student population	41,441	41,573	40,553
Race and Ethnicity			
Minority student population	65%	59%	75%
African American	39%	34%	25%
Hispanic/Latino	18%	17%	46%
Asian American	6%	5%	4%
Native American or Alaskan Native	4%	5%	1%
Caucasian White	35%	41%	25%

CASE STUDY SCHOOLS

	2003	2004	2005
School Locations			
Rural	30%	33%	20%
Suburban	20%	22%	30%
Urban	50%	44%	50%
School Characteristics			
Title I	70%	67%	60%
Low SES student population	69%	48%	43%
Overall student population	7503	5111	7187
Race and Ethnicity			
Minority student population	60%	67%	59%
African American	33%	40%	27%
Hispanic/Latino	23%	20%	28%
Asian American	3%	3%	2%
Native American or Alaskan Native	2%	4%	1%
Caucasian White	40%	33%	39%

Description of the Intervention

The NASA Explorer Schools project was conceived in 2003 to address the nation's and, in particular, NASA's need for students to pursue careers in science, engineering, and technology fields. As stated in the National Science and Engineering Indicators (2003, 2006) report, the number of qualified science and mathematics teachers continues to decline while the number of teachers having to "cross-teach" in science and technical areas where they are not certified or trained continues to increase. Schools serving high-poverty, low-performing, and ethnically diverse students have a lower number of certified science and math teachers. The NES project was designed to address these needs for those schools in greatest need and with the most limited resources.

The NASA Explorer Schools project provides a three-year partnership between NASA and the participating schools to offer professional development, funding for technology resources, STEM-related curriculum activities, materials, expertise, and individual consultation to help teacher and administrator teams achieve the academic goals outlined in their NES sustainability and implementation plans.

The evaluation team looked at field centers from three perspectives. Questions on Team Lead, Administrator, and Teacher Needs/Involvement assessments as well as focus group interviews addressed how **NES teams** viewed the support provided by field centers. The **evaluation team** made firsthand observations of workshops at all 10 NASA field centers and selected special activities to learn how they delivered professional development. The third point of view came from the **field centers** through NES coordinator interviews and Field Center Surveys.

Formative evaluation focuses on the process (Bhola, 1990). Throughout the evaluation period data from assessments, observations, and interviews were collected, analyzed, and shared with NES field center staff so that adjustments to better attain program goals could be made while the process was ongoing. On a higher level the evaluation team not only conducted the evaluation, they explained and modeled formative evaluation, actively including field center staff in the process so that evaluation became institutionalized across NES. While observing onsite and through evaluation sessions at professional development conferences, evaluation team members taught field center staff the importance of collecting data, both through observation and survey, as well as the process of reflection to review and analyze how they deliver the NES program. Formative evaluation was embedded in the process.

Research Design

This study examines the first three years of the NASA Explorer Schools project using a blended methods approach (Green, Camilli, & Elmore, 2006; Chatterji, 2004) that integrates quantitative and qualitative data collected to assess the impact of the NASA Explorer Schools project. This evaluation model used a theory-based evaluation framework based on a clear set of guidelines for examining school, teacher, administrator, family involvement, and student practices and experiences that are associated with the six desired outcomes.

Each school was required to create a set of STEM-related academic goals that they were to accomplish through their three-year partnership with NASA. The specific tools, materials, technologies, and professional development training was selected by schools according to their needs and goals. The evaluation framework examined to what extent participating schools used the NES resources made available and whether the implementation process followed the guidelines for successful professional development practices as outlined in Appendix 1: The NASA Explorer Schools Rubric: Measuring School Success in Achieving the Six Anticipated Outcomes.

As Yin and Davis (2007) caution, evaluations of comprehensive reform efforts like NES require a uniting methodology so that the reform being studied does not have to be evaluated in piecemeal, disconnected assessments. In this evaluation the 30 cluster-based randomized case studies provided a means for studying a coherent picture of the NES three-year partnership intervention project. Integrating the case study method also helps the evaluator demonstrate how the school environment defines the relationship between cause and effect (Supovitz & Taylor, 2005). Since the NES project is designed to be adapted to individual school needs, the intervention implementation is environment-focused and adaptable, which can be documented only through case-based analysis. Thus, the evaluation of NES as a comprehensive STEM-related education reform intervention required both quantitative and qualitative evidence.

Quantitative Design

The quantitative research design was to gauge the impact of NES on the teachers, students, and family level.

Instruments. A variety of data sources were used to collect information about the implementation model and its effects. This section describes the different data sources and their purpose. Table 3.06 provides a summary of data sources and associated analyses.

The Teaching, Learning, and Computing Teacher's Survey is a self-report questionnaire adapted from Becker (2000) that yields data on five constructs aligned with constructivist principles for teaching and learning: technical skill, constructivist teaching strategies, attitude toward technology, constructivist teaching philosophy, and constructivist uses of technology. The scale used to gauge constructivist perspectives and beliefs ranged from 1 (very traditional) to 5 (very constructivist).

The Team Lead Survey was administered to the entire population of team leads (N = 99) from the 2003 and 2004 cohorts. The survey was composed of 20 open-ended and 27 close-ended questions. Data were collected via an online tool (Perception) in January and February 2005. Collected data were aggregated by 2003 and 2004 cohort; there were no posttests available from the 2005 cohort at the time this analysis was completed.

The Student Interest Survey was given in classes of the teachers involved in the NASA Explorer Schools program. The Student Interest Survey was collected in Fall 2005 and Spring 2006. The 2005 fall assessments were required of all NES teams and included online, Scantron, and paper formats of completed assessments representing the whole population of NES students—with the exception of some elementary schools that were given a waiver to this requirement. The 2006 spring assessments were required of all case study schools and were completed either on Scantron forms or online. The case study schools represented a randomly selected group of schools per cohort year with 10 schools selected respectively from the 2003, 2004, and 2005 teams. Non-case study schools were encouraged to complete the Student Interest Survey, and an additional 20 schools did have their students complete this survey. A summary of the sample size distribution of school participation is provided in Table 3.05.

The Student Interest/Career Survey distributed in the spring of 2006 was revised in several ways. First, a shorter, easier to read version was created for grades 4-6. This change was necessary to meet the needs of elementary schools participating in NES. Both the grades 4-6 and grades 7-9 versions of the survey were edited to be compatible with Scantron forms because many teachers reported having difficulty getting access to computers to complete the student interest/career instrument online. Short answer questions were removed or adapted for close-ended responses.

Table 3.05. Sample Completing the Student Interest Survey in Fall '05 and Spring '06

Summary of Student Interest Sample Group for Fall 2005 and Spring 2006						
	2005-Fall Online Grades 4-9	***2005-Fall Scantron Grades 4-9***	***2006-Spring Online Grades 4-6***	***2006-Spring Scantron Grades 4-6***	***2006-Spring Online Grades 7-9***	***2006-Spring Scantron Grades 7-9***
TOTAL Surveys Completed	9,580	3,910	1,964	1,701	2,233	1,549
NASA Explorer Schools	102	19	42		24	21
1st-3rd Graders	108	0	0	0	0	0
4th Graders	375	257	458	375	0	623
5th Graders	766	272	967	883	7	613
6th Graders	1,330	836	518	419	4	189
7th Graders	1,992	884	0	0	849	0
8th Graders	2,301	611	0	0	918	0
9th Graders	489	218	0	0	439	0
10th - 12th Graders	702	173	0	0	0	0
*	1,555	659	21	24	22	124
Gender						
Females	4,039	1,643	932	804	1,098	668
Males	3,996	1,502	1,009	870	1,104	754
*						
Cohort Year						
2003	669	1,651	169	*	191	*
2004	843	1,163	612	*	643	*
2005	154	1,096	912	*	608	*
*	7,914	0	271	*	797	*

* Data not available

Table 3.06. Summary of Data Source and Associated Analyses

Data Source	Analysis
Student Interest Survey	Mixed-design ANOVA
Teaching, Learning, and Computing Survey	Means by construct T-tests for change from year to year of groups T-tests for matched pairs Regression modeling
Teacher Workshop Feedback Form	Means by construct T-tests for change from 2003 to 2005 Posthoc tests comparing among field centers
Teacher Needs (pre) Involvement (post) Surveys	Analyzed after first administration in fall 2005 T-tests for matched schools
Administrator Survey	Baseline summary of responses between 2005 and 2006
Team Lead Survey	Frequency analysis quantitative questions, content analysis for open-ended questions T-tests for change from 2003 to 2005 for 2003 and 2004 cohorts

* Indicates that data were collected in 2005-2006 and were not available for analysis in this report.

Qualitative Design

The qualitative research design was a blend of two complementary approaches: grounded theory (Chen & Rossi, 1983; Lipsey, 2007; Leviton, 2007; Rossi, Freeman, & Lipsey 1999) and case study (Borman, Clarke, Cotner, & Lee, 2006). The grounded theory, as outlined in the theoretical framework section, was based on value-added assessment, empirical research, and scholarship that posits that effective teacher professional development leads to increased student achievement (Au, 2007; Babu & Mendro, 2003; Borko, 2004; Boyle, Lamprianou, & Boyle, 2005; Boyle, While, & Boyle, 2004; Brookings Institution, 2006; Kelly & Monczunski, 2007). The NASA Explorer Schools Rubric: Measuring School Success in Achieving the Six Anticipated Outcomes (see Appendix) summarizes the criteria and guidelines that the grounded theory suggests should be addressed for schools to achieve the desired teacher and student goals.

The case study research design provided a way to systematically collect data from participants that would help us understand how the NES intervention was implemented at the school level. The 29 case study schools were selected from a cluster-based randomized sample design that provided for one school per regional field center per year for each of the three years of this analysis (Jones & Nelson, 2003). In addition to telephone interviews with the NES team, the case study data also included pre-/posttest comparisons of surveys, questionnaires, and school improvement and implementation plans.

All of the data collected was sorted into the interpretational and reflective structure provided by the theory-based framework. After the case studies were written, three researchers individually rated each of the 29 school cases using the grounded theory rubric. The researchers reviewed each school rating and discussed any discrepancy in ratings until a consensus rating was agreed upon by all three raters. The results of the case study ratings provided a qualitative numeric total score and categorical rating that could be compared with quantitative and indirect outcomes (such as student achievement scores) for triangulation and pattern matching of findings.

4. Data Analysis

This final evaluation report builds on work conducted and reported on earlier in this project. The primary questions being addressed in this study emerge from the theoretical framework that has guided the formative evaluation and prior recommendations to the program leadership: How closely does the dissemination of the NES project follow the theoretical framework? How do the actual implementation examples identified via the case studies compare with the outcomes desired by the NES project managers? Both the quantitative and qualitative analyses address these questions. While the quantitative method looks for numeric indicators that can be tested for statistical significance, the qualitative analysis provides interpretive, reflective, and structural evidence to support our understanding of the qualitative aspects of the NES intervention. Below is a description of these two strategies that are ultimately blended together as findings that help us provide a more comprehensive, valid, and reliable assessment of the program and interpretation of the impact that the NES project has had on participating schools.

Quantitative Analysis

For the quantitative analysis of survey reports, variables are first reported in descriptive statistics such as frequency distribution tables. Interpretations of distributions are based on means and standard deviations. Paired t-test, mixed-design of analysis of variance (ANOVA), correlation, and regression statistical analysis were conducted. Paired t-test and mixed-design of ANOVA were to determine inferential statistics on the changes that teachers and students made as the result of NES participation. A correlation analysis was done to identify any correlations among mean rating scores by NES goals across the case studies. Regression was to identify the variables that accounted for the successful outcomes as the result of NES.

Qualitative Analysis

Interviews with NASA Explorer Schools program providers and teacher teams were provided early on in the project. The data sources include 29 cluster-based, randomly selected case study school reports; student demographics; tracking of teacher and student participation in professional development and STEM-related learning opportunities; tracking of technology tools used; and information regarding student performance and achievement. A rubric template was created to conduct a meta-analysis across case study schools (Borman, Clarke, Cotner, & Lee 2006) in terms of the six anticipated outcomes with particular focus on teaching strategies, technology integration, and measures of student interest and achievement. Table 4.01 describes the distribution of rating scores by NES goals.

Researchers pulled the narrative of summary strengths and challenges from case study reports and coded these text comments into the theoretical framework of effective practice drawn from the most recent STEM educational research that reports on what professional development strategies are most effective in achieving increased student interest and achievement in STEM-related areas. The summaries are grouped in three categories—exceeds expectations, meets expectations, and minimally meets expectations—based on each case study school rating in the NASA Explorer Schools Rubric: Measuring School Success in Achieving the Six Anticipated Outcomes. Figure 4.01 illustrates the three groupings by case study scores and provides additional background about each school, including cohort year, whether or not it is a Title I school, and whether the school met it No Child Left Behind Annual Progress Goals in 2003 and in 2006.

Table 4.01. Percentage of Rating Score by Outcome

TOTAL	100%
Teacher growth	48%
Technology assistance	16%
Family involvement	10%
Student interest in STEM	8%
Student knowledge about STEM careers	9%
Student achievement in STEM	9%

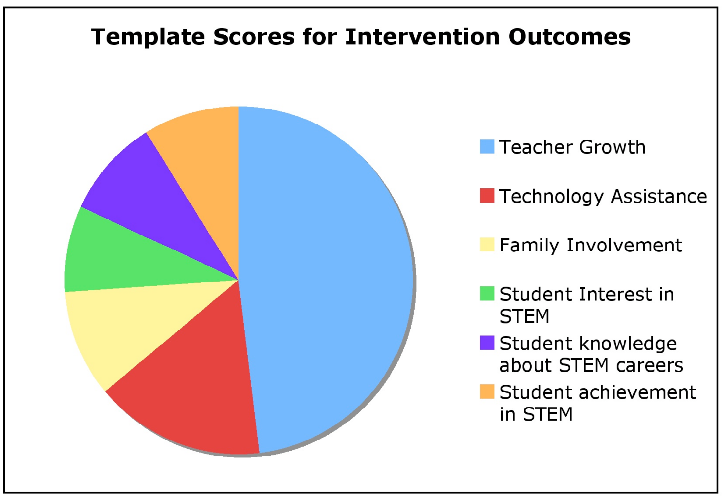

Figure 4.01. This pie chart illustrates the distribution of points across the six NES outcomes. Table 4.01 above lists the percentages of points allocated to the six categories with questions pertaining to teacher growth receiving nearly half of the overall score. This reflects the available data collected from teachers and also the level of investment through professional development time and resource support provided by NES directly to teachers.

Blended Method Analysis

A theory-based professional development framework was applied to conduct a meta-analysis of the qualitative and quantitative data collected over three years to determine to what extent the intervention achieved desired outcomes. This study has implications regarding program theory evaluation: (1) how it can be applied to investigate causal relationships between teaching quality and student achievement, and (2) how it can provide a rigorous conceptual framework from which to assess, improve, and replicate interventions. The researchers applied the theory-based rubric that was used to organize, maintain consistency, and allow cross-case comparisons. Excerpts from the case study reports were used to highlight the breadth of data used and to show in some cases how conflicting data had to be reconciled through further investigation.

Results of the meta-analysis across cases using the rubric template provided a way to compare and contrast the in-depth school cases and highlight successful practices, outstanding achievements, school-specific challenges, and trends evidenced across all cases. A quantitative analysis of the rubric scores for all cases and comparisons across cohort groups helped the researchers identify the most and least successful school interventions. This meta-analysis also yielded new hypotheses that could be tested with existing qualitative and quantitative data. Table 4.02 provides a summary of key school descriptors that are used to group schools for comparison analysis. The scores shown are based on the rubric described earlier and contained in the Appendix.

Student achievement data were collected to compare participating school standing in their district and state the year before beginning the NASA Explorer Schools project with their standing after one, two, three, and four (one year post completion) years of participation.

Table 4.02. Case Study School Ratings in Terms of Rubric Score, Cohort Year, AYP 2003-2006

Case Study School Code	***Cohort Year***	***Title 1 School (y=1; n=2)***	***Met AYP 2003 (y=1; n=2)***	***Met AYP 2006 (y=1; n=2)***	***Total Score on NES Rubric***	
D109	2004	2	1	1	93	**Exceeds expectations**
J22	2005	1	1	1	88	
B103	2004	1	1	2	83	
B72-A	2005	1	2	1	81	
B72-B	2005	1	1	1	81	
I59	2003	1	1	1	78	
H99	2003	1	2	2	78	
C6	2003	1	1	1	77	
H6	2005	1	2	1	77	
E57	2003	1	*	1	74	**Meets expectations**
A42	2003	1	2	2	74	
F59	2005	1	1	1	74	
J71-A	2003	2	2	1	73	
I38	2005	1	1	1	72	
E25	2005	1	1	1	71	
I16	2004	1	2	1	69	
J71-C	2003	2	*	*	68	
J71-B	2003	1	*	*	67	
G145	2003	1	2	2	66	
F87	2004	1	*	*	66	
C14	2005	1	2	1	65	
F18	2003	2	1	*	64	
A126	2004	1	1	1	63	
A104	2005	2	2	2	63	
E98	2004	1	2	2	62	
G110	2005	1	1	2	62	
D143	2005	1	2	2	61	
B1	2003	1	1	1	56	
C103	2004	1	*	**	54	**Meets Minimum Expectations**
J65	2004	2	*	2	53	
D106	2003	1	1	1	52	
H16	2004	1	**	***	44	

*information not available
**Composite grade D alert
***School restructuring for middle school level English and Language Arts

Case study analysis shows that teachers were able to apply what they learned from the NES professional development training in spite of significant challenges in terms of time, administrator and team changes, and curriculum restrictions.

“Two of the NASA Explorer School team members at Key Peninsula Middle School, participated in Winter's Story 2007. Mrs. Borders is anticipating high levels of student engagement and involvement as the Winter's Story materials are integrated into 8th grade science classes. Mrs. Borders' 8th grade students will complete a weather and climate investigation during second semester. The Astronomy and Aerospace students will investigate space weather, examine the conditions for life, and study geological processes on Earth and on other planets. The Astronomy and Aerospace class will also design and lead activities at a spring NASA Family Night.[3]

[3] Source of photograph and quote: e-Folio (2007).

5. Findings

Since detailed reports on the NES surveys were provided in Briefs 4 and 5, this section highlights the most significant findings from across all surveys. Researchers select specific questions and summary data to present in table format and to discuss in the narrative of this section. Each data table includes the appropriate test of statistical significance and, if significant, by a measure of association, comments regarding the relative strength of the variables' association. The findings begin with a summary of the NES implementation model and the NASA field center role in administering the program to schools on a regional level.

Brief 4 (Davis, Palak, Martin, & Ruberg, 2006) examined how the program is being implemented by examining the role of NES headquarters, field center staff, and NES school teams over the first 18 months of the program. Here, we highlight the key findings that have important implications for understanding the effectiveness of NES.

NES is a top-down, school team-based intervention. NES project managers provide the following administrative services on a national level:

a. Disseminating funds and program planning and leadership to support the organization and implementation of the program.
b. Orchestrating communications and coordination of support for the field center staff and schools.
c. Garnering and organizing support from within NASA for the field centers and schools.
d. Initiating professional development services and support for cross-cutting activities for the schools, such as for professional development workshops (Winter's Story, SEM-B, regional and national conferences).
e. Offering curriculum review and development specific to inquiry and the needs of NES schools.
f. Conducting outreach, application, dissemination, and publicity services to promote NES opportunities at minority institutions, professional teacher organizations, and STEM professional societies and groups.
g. Contracting for program and outcomes evaluation.

While headquarters provided administrative services, NES coordinators served as the main contacts for schools at the field centers to respond to questions and provide services and support. NES coordinators come from STEM backgrounds in K-12 education, so they were able to help the school teams implement the program and advise them on strategies and ideas for accomplishing their goals. NES coordinators worked with the schools' team leads to share successes and challenges and to develop ways to integrate best practices into the professional development offered by the field centers. The NES coordinators also worked closely with aerospace education specialists and other field center staff to help schools select NASA resources that addressed specific STEM needs and goals at the schools. Aerospace education specialists provided onsite support for schools. In fall 2005 Digital Learning Network coordinators were added to five field center teams to support the NES schools' use of the network.

The schools selected for the NES project are high-minority, high-poverty, ethnically diverse, and previously low-achieving schools in great need of help to address national goals for improving student STEM achievement. Once a school is accepted into the program, it completes a needs assessment profile of school academic priorities. The assessment is used as a reference for the development of strategic and implementation plans that identify how NASA resources and services will be used to meet STEM academic goals. The five-person NES team from each school develops these plans with support from field center staff. The staff encourages and supports the team in taking a leadership role in involving the school, community, and local partners in the reform effort.

Outcome 1
Participation and Professional Growth of Educators in Science

Guideline 1. Teaching Strategies to Engage Students in STEM Learning

Teachers who fully integrate the NES intervention apply what they have learned about inquiry methods to create learning environments that immerse students in hands-on investigations and cooperative learning activities. Optimally, successful NASA Explorer Schools will use what they have learned from NES professional development opportunities to integrate teaching strategies in STEM subjects that (1) immerse students in scientific inquiry, questioning, and experimentation; (2) involve students in the process of generating and evaluating scientific evidence; and (3) model scientific reasoning.

Table 5.01 provides a summary of implementation and challenges to implementation of teaching strategies at the case study schools. Only those cases that presented their implementation successfully or as challenging are listed here.

Table 5.01. Implementation of Teaching Strategies to Engage Students in STEM Learning

Successes	***Challenges***
H99 curriculum changes included increased block scheduling for STEM; in 2003 the state review team praised H99 for providing a new set of learning objectives that can be easily tracked by examining student work samples.	H99: Lack of a system to document teaching strategies used and how they tie to learning objectives; no way to monitor whether defined teaching strategies are being implemented; no plan to track teacher use of instructional strategies with objectives
G145 had its biggest breakthrough during the 2004-2005 school year. Twice that year the school had block schedule days in which it selected a STEM topic and had that topic integrated through the entire school with all teachers basing their classroom lessons that day on the same topic. In the fall the topic was aeronautics; in the spring it	G145 lags behind the state average in achievement scores and has had restrictions on how it can incorporate NASA activities into classroom teaching.

Successes	***Challenges***
was microgravity. The entire school got involved.	
J22 integrated NASA information across their curriculum, creating NASA Tiger TV, a combination of communication arts and NASA content.	
C6 worked with each other using NASA materials to develop coherent STEM instruction and strategies for all the students.	`
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.	
F18 non-science teachers are doing interdisciplinary study with students.	
A104 has opened some new curriculum to their students, such as in astronomy and aeronautics, robotics, and space technology, as a result of their involvement in NES. A total of 90-120 students signed up for these new classes.	
E25 teachers utilized inquiry-based learning lessons through NASA resources, including webcasts, coupled pendulum activity, beluga whale activity, Echo the Bat activity, and the Night Sky activity.	
D106[4] did not have a science program before 2003. Students experienced science activities and materials through the NES school partnership with NASA.	

Thus, the case study analysis shows that teachers were able to apply what they learned from the NES professional development training. School application of new teaching strategies varied greatly with some describing using inquiry techniques, several schools introducing block scheduling, and others introducing new curriculum opportunities at their school as a result of their participation in NES. The challenge described by H99 in which they describe documenting new teaching strategies, tying these to specific learning objectives, and then tracking results would be useful to many of the NES teams who also need to further document their instructional practices.

[4] School codes shown in italics represent the four schools that only minimally met the criteria for successfully implementing the NES program. These schools are highlighted in the case study comparisons to show that these schools were successful in addressing several aspects of the program. These schools also described more difficult challenges that had to be addressed in order to implement the NES intervention activities.

Teacher Involvement Pre-/Postsurvey Responses to Questions About Teaching Strategies

The Teacher Involvement Survey pre-/posttest analysis showed a significant decline in teacher self-ratings regarding how much they use inquiry approaches in their instruction (See Table 5.02). This is an area where NASA field center staff and other workshop trainers need to help NES teams find ways to practice as is suggested in the first challenge presented in Table 5.01. It advises teachers to document teaching strategies used and how they tie to learning objectives…[so that teachers can] track use of instructional strategies with objectives. The research team also found that some NES workshop sessions had to be reminded to allow teachers time to digest what they are learning and give them time and some facilitated support to address integration of NASA resources at the time of training.

Table 5.02. Team Lead Survey: Paired Samples Statistics
STEM question: How much have you changed in each of the following areas as a result of being in a NASA Explorer School?

	Pretest mean (SD)	Posttest mean (SD)	N pre (post)	Pre-/ Posttest comparison
Incorporate inquiry approaches into instruction	3.89 (1.05)	3.58 (1.08)	347 (347)	↓ 0.000

Outcome 1:
Participation and Professional Growth of Educators in Science

<u>Guideline 2. Time Commitment to Implementation of NES Intervention</u>

The case study and survey data collected to address this guideline examines what workshops and conferences offered by NASA (or partnering organizations such as the National Science Teachers Association) did school teams attend and what level of satisfaction with the professional development experiences did teams report. In this instance workshop evaluations and teacher responses to workshops and other curriculum training opportunities provide insight into teacher ratings of the value of the workshop as well as teacher efforts to connect the NES learning opportunities to their individual professional development plan. The first section summarizes teacher reflections on NES professional development experiences. The second section of this examination of teacher time commitment to NES professional development opportunities integrates findings from teacher survey reports and workshop evaluations.

The case study schools reported that steps taken to leverage partnerships with other NES schools and other non-NES teachers were key ingredients of their time commitment to and level of participation in NES professional development offerings. Teachers described the difficulties of finding enough time to handle their existing duties and fulfill their NES responsibilities. Some school teams found ways to manage; others reported frustration in not being able to spend as much time on NES as they had intended (See Table 5.03).

Table 5.03. Case Study Analysis: Time Commitment to Implementation of NES Intervention

Successes	***Challenges***
D109 successfully built partnerships with other NES schools and credits these connections with greatly impacting the school and students.	D109 reported, "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."
E57 has involved other non-NES teachers in professional development activities, and feedback from non-NES teachers has been positive and encouraging.	I59 expressed concern as to whether the improvements they made for their students would be supported in a coherent fashion in middle and high school. At this time the middle school that students from I59 matriculate to is classified as needing improvement by the state review board.
F18 has involved special education teachers and students in the NES program. The F18 team perceives the involvement of the entire school population as one of the important goals of the NES team.	I16: 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 NASA field center serving I16 presented a problem with forms not being turned in on time.
I16 described increased opportunities for professional development for teachers and opportunities for teachers to present to colleagues at professional conferences.	J71: Trying to get non-science or math teachers involved in NES has been a challenge. There is a lack of excitement from teachers who are not directly teaching science or math.
C14 made professional development opportunities available to all of its staff, even extending beyond the elementary school staff to include the junior high building.	C14 team members cite lack of time as a challenge. However, they seem to overcome this challenge by willingly doing most of the NES planning outside of school hours. The NES coordinator identified C14 as a successful school, citing schoolwide involvement in NES, use of DLN, use of AES for professional development and students, non-NES grants, and regular communication with the NES coordinator as contributing factors for C14's success.
D143 has made its non-NES teachers aware of the NASA online resources and the Educational Resource Center (ERC).	E98 field center coordinator listed communication with the E98 team as being difficult due to lack of response from the E98 team.
E25 hosted 4 on-site workshops in 2005 and expanded to 12 in 2006 by aerospace educators in addition to professional	E25 saw participation in NES meetings as taking team teachers out of their classrooms and away from teaching.

Successes	***Challenges***
development through regional and national conferences and workshops provided by NES.	
G110 initiated activities to create schoolwide enthusiasm about being an NES school, which included opening a mission patch contest to all students, holding a kickoff event, creating a huge mural featuring the winning mission patch in a school hallway, and hosting an astronaut visit. Teachers report that these startup activities generated pride and interest among the students.	G110 describe their having poor communication and lack of timely responses from the field center staff, which frustrated the team. The G110 team administrator created her own contact directory, but was unclear about which contact to call for specific needs. The NES program provided a notebook, but the G110 team found it too unwieldy and large. Taking advantage of opportunities was sometimes difficult because of a disparity between the quick response required by the NES program and the actual time needed to get permission from the school district.
I38 established a NASA-rich environment by immersion in space themes throughout the school through the addition of a large space mural, NASA-themed bulletin boards, and NASA STEM activities.	I38 initially encountered jealousy from non-team teachers, but they have since alleviated it by sharing professional development opportunities and including non-team teachers in NES schoolwide activities.
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.	A104: Non-team teachers have been difficult to engage. They don't have time to search for and review NASA resources or activities.
	C6 reported that lack of time combined with the vast amount of information available for teachers is one of the biggest challenges for their NES team. NASA offers so many educational resources for teachers, and while this should be a benefit, sifting through all this material takes time. Teachers reported spending a large amount of time preparing lessons using NASA materials. Most NASA resources are for the fifth and sixth grades, teachers said, which led to problems identifying appropriate materials for third and fourth grades.

Evaluation of Workshop Quality Throughout the Field Centers by Teachers

When comparing teachers' responses to the workshop quality on different field centers, we found there is a significant difference on teachers' responses to the questions as represented in Table 5.04. In the responses to teachers' confidence in their ability to apply the knowledge and skills learned, teachers who participated in 2005 workshops rated higher than teachers in the 2003 and 2004 workshops. In Table 5.04 we also learned that teachers who participated in the 2003 workshops rated highest on how the workshops helped them to gain a better understanding of NASA's mission, gain better understanding of NASA's support for education, and inspire their students. We also found that while there were some differences on how teachers rated differently each year, these ratings were not significant. This implies that the workshops provided by the field centers each year obtain levels of quality that are equally distributed.

Table 5.04. Summary of NES Orientation Workshop Ratings by Year

	2003 Year			2004 Year			2005 Year		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Q3. After participating in the event I feel confident in my ability to apply the knowledge and/or skills learned.	10	4.36	0.38	9	4.50	0.31	10	**4.52**	0.09
Q5. I have a better understanding of NASA's mission.	10	**4.81**	0.16	9	4.79	0.20	10	4.64	0.19
Q7. I have a better understanding of NASA's support for education.	10	**4.85**	0.15	9	4.77	0.19	10	4.68	0.18
Q12. Inspiring my students.	10	**4.86**	0.18	9	4.84	0.11	10	4.84	0.07
Q13. Increasing family involvement.	10	4.46	0.37	9	**4.54**	0.26	10	4.44	0.20

We found two items with statistically relevant differences across all 10 field centers:

- After participating in the event, I feel confident in my ability to apply the knowledge and/or skills learned.
- Increasing family involvement.

Figure 5.01 represents where significant differences reside by year for each field center for these two questions. In 2003 three field centers received below 4.0 from teachers' feedback on whether the workshop increased their ability to apply the knowledge or skills learned. In 2005 all the field centers received 4.0 and above scores from the teachers on whether the workshop increased their ability to apply the knowledge or skills learned.

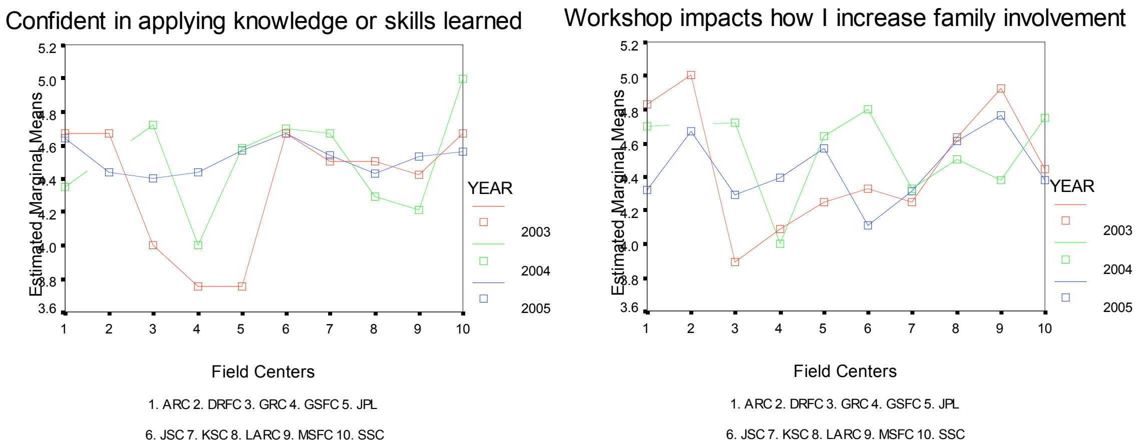

Figure 5.01. Teacher ratings of their experiences with each field center over the course of three years that the workshops were collected and analyzed. The ratings illustrated here are specifically for the items "Confident in applying knowledge or skills learned" and "Workshop impacts how I increase family involvement."

The two graphs in Figure 5.01 illustrate workshop means for each of the 10 NASA field centers by year. The graph on the left illustrates the differences in ratings across centers for teacher ratings regarding how confident they feel in their ability to apply knowledge or skills learned at the orientation workshop (see Table 5.04). Several centers that received lower scores on this question in 2003 and 2004 raised their scores to equal the cross-center mean by 2005. The graph on the right shows that Orientation workshops are not receiving consistent ratings by teachers for their family involvement training.

The graphs provided in Figure 5.01 show that while workshop ratings overall have been consistently above 4.2, variations in workshop quality were evidenced in the first two years of the NES program, but these differences were addressed in all areas except family involvement training.

Team Lead Survey Ratings of Benefits of NES Professional Development and Support

The Team Lead Survey was given twice to all 2003 and 2004 team leaders. This survey was designed to collect team leader observations and perceptions of their Explorer School team and schoolwide implementation of the program, accomplishments, challenges, and design decisions through a web-based questionnaire format. The first version of this survey was completed between January and April 2005; the second, revised version was completed between February and May 2006. Expanded data reports on the Team Lead '05 and '06 surveys are provided in Briefs 4 and 5 respectively. The data collection summary matrix provides a list of constructs addressed by this survey.

Paired Sample

The 64 matched pairs represent all 10 of the NASA field centers but only the 2003 and 2004 cohorts. Most of the respondents are teachers; however, the 2006 version of the survey shows that team leader roles have become more specialized, and the team leader role varies from team lead teacher to administrative lead to family involvement leader.

Questions from the 2005 to 2006 version of the Team Lead Survey that could be matched for comparing mean scores and that are most relevant to understanding how teachers align pedagogical content gained from NES with their school and district standards of learning are listed below.

Table 5.05. Team Lead Survey: Paired Samples Statistics

	Pretest mean (SD)	Posttest mean (SD)	N pre (n post)	Pre-posttest comparison (effect size)
1. Has your NES team membership changed since orientation workshop?	1.52 (0.50)	1.71 (.46)	63 (63)	↑ 0.002 (.02)
2. To what extent are you satisfied with support from NASA staff?	4.53 (0.73)	4.34 (1.53)	58 (58)	N.S.
3. How important has your implementation plan bee to your NES team this year?	3.25 (0.72)	3.11 (0.83)	62 (62)	N.S.
4. How much has your school benefited from being a part of the Explorer School program?	4.30 (0.83)	4.78 (1.01)	63 (63)	↑ 0.0003 (0.009)
5. How satisfied or dissatisfied would you say most team members are about being in the NES program?	4.45 (0.62)	4.29 (1.14	62 (62)	N.S.

The paired T-test analysis presented in Table 5.05 shows that the differences in mean scores for pairs 1 and 4 were significantly different in the 2005 to 2006 surveys. The findings from questions 2, 4, and 5 are most relevant to this section that addresses NES team views about the value of NES professional opportunities. Discussions of questions 1 and 3 are reported under outcome 1, guideline 5.

Discussion of Question 2: There is a small decrease in the mean score rating of team lead satisfaction with the overall support your school has received from NASA staff between the 2005 and 2006 surveys. The decrease in mean score ratings are not statistically significant but are correlated. This rating decrease may highlight the fact that NES coordinators increased the number of schools that they were handling between 2005 and 2006. In 2005 there were two cohorts to support, and in 2006 there were three with a new cohort joining in the summer and a graduating cohort to continue to assist to some extent in 2006.

Discussion of Question 4: Team lead ratings of the benefits of the Explorer School program showed an increase from the 2005 to 2006 survey that was significant at less than .001 level. This is consistent with the hypothesis posed that teachers' recognition of the benefits of participation in the program increases over time. Many of the anticipated outcomes cannot be achieved within one year and require multiple years of participation and implementation of the program in order for the desired outcomes to be manifested.

Discussion of Question 5: The mean scores reflecting team member ratings of their satisfaction with the in the Explorer Schools program did not increase between 2005 and 2006, but the decrease was not statistically significant. Team lead responses to this question were also not correlated, which suggests that team lead responses reflected different expectations, experiences, and possibly different kinds of support both at school and from NASA field centers.

Thus, the analysis of the pre-/postsurveys completed by NES team leads suggests the following trends across the 2003 and 2004 NES school cohorts:

- Team lead ratings of their satisfaction with the overall support their school received from NASA over the past year declined slightly, but not significantly. This may reflect that schools receive less support over time as new NES schools are brought in each year and more attention is focused on the newer schools.
- There is a statistically significant increase in team leads' rating of the benefits of their participation in the NES project over time. This finding supports the need for the multiple year partnership demonstrating that the benefits become significantly stronger the longer a school is in the program.
- Individual team member satisfaction with being in the NES program remains between satisfied and very satisfied after multiple years and in spite of the time commitment required.

Administrator Concerns About Time Required to Implement the NES Project

Table 5.06 shows that administrator concerns are consistent across three cohorts. About half of all administrators are concerned about the time it takes teachers to implement the program. A majority of administrators (72-80 percent) are concerned that the NES program may be overwhelming. About half of all administrators are concerned about the time it takes them to coordinate the program. These results indicate that administrators are concerned about NES program implementation efforts throughout the startup, integration, and sustainability years.

Table 5.06. Administrators' Internal Concerns About the NES Program

Administrators' Concerns	**2003**		**2004**		**2005**	
	(%) No	(%) Yes	(%) No	(%) Yes	(%) No	(%) Yes
Concerned about the time it takes teachers to implement the program	44	53	46	54	47	53
Concerned that the NES program may be overwhelming	72	28	78	22	80	20
Concerned about the time it takes administrators to coordinate the program	50	50	54	46	45	45

Administrator Satisfaction with NES Implementation

Table 5.07 shows that administrator satisfaction regarding four major components of the NES program is consistent across the three implementation years. An overwhelming majority of administrators in all three cohorts are satisfied with the program's emphasis on teacher professional growth, student STEM learning, student STEM career interest, and family involvement.

Table 5.07. Administrators' Current Satisfaction with the NES Program

	2003		2004		2005	
	(%) No	(%) Yes	(%) No	(%) Yes	(%) No	(%) Yes
Satisfied with the emphasis on teacher professional growth	6	92	4	94	4	86
Satisfied with the emphasis on student STEM learning	3	89	2	90	0	88
Satisfied with the emphasis on student STEM career interest	6	84	2	92	2	84
Satisfied with the emphasis on family involvement	6	84	4	92	6	86

Outcome 1
Participation and Professional Growth of Educators in Science

Guideline 3. Classroom Practices: Integration of NASA Resources to Encourage Student Engagement

This category looks closely at how NES teams integrated NASA products, curriculum materials, and expertise such as the aerospace educators to engage their students in STEM-related topics and careers. The researchers looked for evidence to show how teachers aimed their teaching strategies and materials toward improving STEM (including geography) instruction as well as in English, reading, and language arts (See Table 5.08).

Table 5.08. Case Study Analysis: Integration of NASA Resources to Encourage Student Engagement

Successes	***Challenges***
D109 reported that aerospace educators 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.	D109 found that some NASA activities are time consuming to implement. NASA resources are very limited for grades K-3. The delays in receiving funding have caused some delays in carrying out the implementation plan.

Successes	***Challenges***
C6 teachers and students are now engaged more deeply in science because of their direct access to NASA scientists made available through NES, and more resources and materials to support scientific inquiry are now available to all K-6 students.	C6 lack of ongoing support and use of materials was a challenge. The implementation plan outlines the school goals, but they have found these goals to be unrealistic. Teachers want constructive and timely feedback on the goals they set as their school outcomes.… NASA offers so many educational resources for teachers; sifting through all this material takes time; teachers reported spending a large amount of time preparing lessons using NASA materials.
B72 Each NES team member implemented in their classroom a NASA program that had not been used before at their site.	F59 schools are required to follow very strict guidelines regarding curriculum and testing, which made finding time for implementation of the NES program a challenge.
J71 teachers are inspired by seeing NASA educator and scientist level of passion for what they are doing. The opportunity to attend different professional development workshops has helped teachers network and meet with other educators. The discussion with other teachers gives J71's teachers fresh ideas for teaching and learning.	J71 has had a problem communicating with NASA. The space agency has so many resources and materials, yet finding the right thing sometimes is not possible or is too time consuming.
E25 successfully incorporated NASA curriculum and activities into their regular school calendar.	E 25 notes that the Hurricane Katrina disaster affected its implementation of NES.
D143 has used NASA curriculum to meet academic needs. The curriculum has been used schoolwide with students, primarily in science classes. D143 has created an atmosphere promoting NASA through bulletin boards in their cafeteria kept up to date with information about science, NASA, and science exploration.	B1: The main difficulty is that the time required to adapt and integrate NASA materials takes them away from their duties in lesson planning and time to work with students.

Successes	***Challenges***
	E57 reports that the field center is not as available as the E57 team would have liked. The team has been told that the field center had too many other schools and can only visit the school a small number of times. In addition, a natural disaster, Hurricane Katrina, caused delays in the implementation process. The help from the NASA field center was limited because it lost its workshop areas too. E57 also lost a lot of instructional time because of Hurricane Katrina.
	F87 noted that 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.
	I16 reported that integration of NASA resources has been somewhat challenging.
	A104 team reports that lacking a clear focus, it is difficult for A104 teachers to select resources to support activities for the whole school or families.
	H99 worked closely with aerospace educators and field center staff to make curriculum changes: schoolwide teacher training, increased block scheduling for science and technology curriculum, and access to NASA opportunities for as many students as possible.… The 2003-2004 School Improvement Plan identified gaps in student learning based on a careful and thorough analysis of student test results.…[the H99 team] oriented [their NES] plan around teaching and learning targets.
	G110 team members experienced difficulty getting on the calendar to receive aerospace education specialist services. Integrating NASA resources into the curriculum was extremely difficult for G110 teachers in grades 5-7 because their areas of academic concentration are math and reading, not science.

Outcome 1
Participation and Professional Growth of Educators in Science

Guideline 4. Teachers Demonstrate Increased Knowledge of STEM Content and Use of Inquiry

This category examines teacher reports or demonstrations of increased knowledge of (and/or skills in) STEM content, STEM careers, and ways of integrating STEM education into family involvement activities (See Table 5.09). In addition to teacher learning of STEM content, this category also looks for evidence of teacher growth in pedagogical areas, especially regarding use of inquiry, but also including classroom management strategies, lesson planning, or grouping methods gained by NES professional development.

Table 5.09. Case Studies: Teachers Demonstrate Increased Knowledge of STEM Content and Inquiry

Successes	***Challenges***
H99 worked closely with the NASA aerospace education specialist and field center staff to make their curriculum more inquiry based and hands on.	A42 has lower than average percentage of teachers with advanced degrees—the A42 average is 6 percent lower than the district average, which makes advances in STEM content and pedagogical strategies more difficult.
C6 noted that more resources and materials to support scientific inquiry are now available to all K-6 students. Teachers trained on science content and technology tools to promote students' learning. Teachers and students are engaged more deeply in science because of their direct access to NASA scientists.	I16 statistics show that only 31 percent highly qualified (certified in content area) teachers in secondary classes are teaching core subjects.
D143 has involved its field center staff in some of its science experiments.	Before participation in the NES project, *D106* did not have a science program. Now, because of low student performance on reading tests, teachers get sanctioned if their students do not show improvement in language arts, and it is hard to convince others to take time for science.

Team Involvement Pre-/Postsurvey on Content Knowledge Change

As presented in Table 5.10, team leads showed significant increases in their comfort level in teaching science concepts. There is no statistical significance in teaching mathematics concepts. Team leads showed significant decreases in their comfort level in teaching concepts such as educational technologies, engineering, technology education, robotics, and geography. The findings from team leads on their lack of comfort in teaching technology-related concepts may be associated with teachers' showing no increase in their technical skills when it comes to dealing with technology (see Table 5.20 for more information from the teachers' survey on teaching, learning, and computing).

Table 5.10. Team Lead Survey: Paired Samples Statistics

STEM question: How comfortable are you teaching concepts in the following areas?				
	Pretest mean (SD)	Posttest mean (SD)	N pre (post)	Pre-/Posttest comparison (effect size)
Science	3.98 (0.94)	4.05 (1.02)	348 (348)	↑ 0.000
Educational Technologies	3.89 (0.97)	3.62 (1.10)	348 (348)	↓ 0.000
Engineering, Technology Education, Robotics	2.56 (1.06)	2.3 (1.24)	349 (349)	↓ 0.008
Mathematics	3.86 (1.01)	3.9 (1.06)	349 (349)	N.S.
Geography	3.67 (1.01)	3.56 (1.12)	344 (344)	↓ 0.016

Outcome 1
Participation and Professional Growth of Educators in Science

Guideline 5. Teachers Align Pedagogical Content Gained Through NES with Standards of Learning

This criterion documents evidence that NES teams discussed standards alignment of NASA STEM activities or that teachers demonstrated use of (pedagogical content) inquiry, classroom management, lesson planning, or grouping methods gained by NES professional development (See Table 5.11).

Table 5.11. Case Studies: Teachers Align Pedagogical Content Gains with Standards of Learning

Successes	***Challenges***
B103 teachers brought their curriculum/standards in line with state standards. Through the [NES] sustainability grant they were able to hold three staff workshops to develop a new curriculum map.	C6 found that most NASA resources are for the fifth and sixth grades, which led to problems identifying appropriate materials for third and fourth grades. Teachers also describe personality conflicts among team members. "Although there are ongoing conversations between teachers, it has been difficult to work with one another."
D109: The [original] 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.	D109 reported that scheduling team meetings is difficult.
H99: The NES planning team has expanded to 10 members, 4 members of the original NES group. This group meets monthly to plan and carry out STEM-G-related PD curriculum integration and community (family) events.	I59 faced difficulties based on a lack of access to high-quality, STEM-certified teachers.
E57 teachers now share their activities and strategies with each other.	B72: Negotiating the distance between team schools and different cultures was a challenge.

Successes	***Challenges***
G145 has had consistent NES team leadership and stability. The team lead is a grade 6-7 science teacher; team members have been the same since 2003. The team meets once a month formally to plan, discuss how money will be spent, order materials, and coordinate upcoming programs. The team works together in the school to lead, create, and apply the NES program, and the team tries to involve other teachers and ensure it is properly staffed.	I59 has about 15 to 25 percent of STEM-related classes that are taught by teachers who are not highly qualified (certified in that content area).
E25 was able to meet regularly (twice each month) to monitor progress and make plans.	H6 professional development days were taken back. The team overcame this by doing professional development during team meetings or having the team lead meet with faculty and students.
B1 team members feel that they have been successful in their efforts to include teachers from outside the core team from the beginning of the NES project. Team members report that they work together well, complement each other's strengths, and encourage each other to pursue areas of specialization.	A42 faculty developed an aeronautics and aerospace curriculum designed to incorporate NASA and STEM-G lessons and activities for students in pre-kindergarten through fifth grade.
	F18: Changes in administration has slowed down the implementation process. It takes a while for the new administration to get acquainted with the NES project.
	G145 has experienced some challenges associated with having five personalities work together so closely. Attempts to build schoolwide collaborations have not always been successful. Some team members reported a lack of cooperation from the staff, which was frustrating.
	J71 found that having three schools on the NES team is a challenge. Schools vary a lot even within the same district. Team turnover is also a challenge faced by the J71 team. For example, when the principal changes, the new principal does not understand either how the program was being implemented or does not buy into the NES mentality.

Successes	***Challenges***
	A126 teachers said they used to have some conflict in personality issues among team members. Ongoing conversations and adjustments have helped to resolve the problem.
	F87 found that changes in team membership and in team leadership have caused delays. New members have not received any training, and they are having a difficult time catching up with the implementation schedule. 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.
	I16 reports that at the school level, dysfunctional administration and/or staff, weak team, and team turnover (due to health issues of the team lead) created difficulties for this school that field center staff observed.
	D143 found it challenging to integrate NASA resources into the curricula because each department has "pacing charts" that they are required to follow.
	F59 changes in administration created challenges. "There have been many challenges at the school. Next year, there is a possibility there will be more changes. We have sitting here an administrator who has been changed twice this year. One vice principal left right after we got the award to be a NASA NES school, and then the principal left a few weeks ago. Out of the six people sitting here, I am new and two or three of the others may be leaving next year."
	G110 had two team members go on maternity leave, and this caused continuity problems in terms of team roles and implementation of NES.
	I38 encountered a lack of support from its district central office.

Successes	***Challenges***
	H16: 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 schoolwide in teachers, staff, and administrators. To illustrate how disruptive the turnover can be, *H16* has had three principals in a single year in addition to loss of faculty members.
	D106 teachers report that having a lack of common time to plan for the next event or next series of events hinders their ability to collaborate on implementing new activities, reviewing what has been done, and planning future STEM-related activities. Infrastructure challenges within the school community have led to changes in the school NES team membership, and as a result, the weekly NASA science rotation eventually was discontinued.
	C103 has struggled to find a time for team meetings. Not meeting regularly has produced some chaos within the team.
	J65: 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 have difficulty finding common time to meet or sponsor any in-house professional development workshops during school time.

Evidence from Team Lead Survey of Teachers Engaged in Active Learning

As described in the theoretical framework section of this report, NES team teachers and their administrator need to be able to meet at least monthly to discuss STEM-G curriculum materials and teaching methods and to plan and reflect on NES implementation. As one of the case study schools reported, “Not meeting regularly has produced some chaos within the team." Team leads were asked several questions about their team dynamics and meeting schedule. Below are some highlights of these findings.

Regarding team dynamics, NES 2003 and 2004 cohort team leads were asked:

1. Has the membership on your Explorer School team changed since attending the NASA summer orientation workshop?

    Possible answers: 1) Has changed; or 2) Has remained the same.

Discussion of Question 1: NES team lead responses to this question showed a statistically significant increase (see Table 5.12). Membership on NASA Explorer School teams showed greater changes in the 2006 survey than in the 2005 survey. The summary of mean scores in Table 5.12 shows that about half the teams changed members in 2005, and about 75 percent changed members in 2006. As Table 5.12 shows, the pre/post responses for Pair 1 are highly correlated, which shows that those school teams that had initial changes in 2005 also tended to have team changes in 2006; correspondingly, those school teams that did not change in 2005 tended not to change in 2006.

3. How important has your implementation plan been to your NES team this year?

    Possible responses: 5) Extremely important; 4) Very important; 3) Important; 2) Somewhat important; or 1) Not important.

Discussion of Question 3: The decrease in team lead ratings of how important the implementation plan has been to the school NES team this year is consistent with the diminished role that this process is now given. The implementation plan has been replaced by the NES web-based portfolio (http://aesp.nasa.okstate.edu/efolio/), which was designed to offer a systemwide guideline for strategic planning and was adopted in January 2006. Although the change in ratings for the importance of the strategic plan was not statistically significant, the 2005 and 2006 paired ratings were correlated.

Table 5.12. Team Lead Survey: Paired Samples Statistics

	Pretest mean (SD)	Posttest mean (SD)	N pre (n post)	Pre-/Posttest comparison (effect size)
1. Has your NES team membership changed since orientation workshop?	1.52 (0.50)	1.71 (0.46)	63 (63)	↑ 0.002 (.02)
3. How important has your implementation plan beeN to your NES team this year?	3.25 (0.72)	3.11 (0.83)	62 (62)	N.S.

Teacher Involvement Survey. As Table 5.13 shows, teacher responses to the question on the Teacher Needs (pretest) and Teacher Involvement (posttest) surveys showed a slight (but not significant) increase in their self-ratings regarding their doing more to align their instructional approaches to reflect national and state (and district) standards of learning in STEM areas. As the qualitative data provided in the beginning of this section shows, those schools that specifically mention meeting as a team, regularly planning, and carrying out STEM curriculum integration scored at least in the “meets expectation” category in their rubric ratings for implementation of the NES intervention.

Table 5.13. Teacher Involvement Survey: Paired Samples Statistics
STEM question: How much have you changed in each of the following areas as a result of being in a NASA Explorer School?

	Pretest mean (SD)	Posttest mean (SD)	N pre (n post)	Pre-/Posttest comparison
Align instructional approaches to reflect national state standards	3.24 (1.35)	3.31 (1.18)	347 (347)	N.S.

Evidence from Administrators' Support to the NES Teams Engaged in Active Learning

Table 5.14 shows that administrator involvement with NES activities increases over time. This is promising despite the finding of frequent administrator turnover in most NES schools. Administrator involvement with all the activities listed is above a 3.0 average, which indicates administrator involvement and support for the NES intervention. With the exception of implementing lasting changes to district policies based on the team's strategic plan, administrators across three cohorts reported involvement in NES activities on at least a monthly basis.

Table 5.14. Support Administrators Provided to the NES Team at School

	2003		**2004**		**2005**	
	(%) No	(mean) Yes	(%) No	(mean) Yes	(%) No	(mean) Yes
I have actively participated in the implementation of the team's strategic plan at our school.	0	3.41	0	3.30	2	3.34
I have represented the team's interests and concerns to higher levels of administration.	0	3.61	0	3.52	2	3.38
I have helped implement lasting changes to school policies based on the team's strategic plan.	6	3.16	6	3.10	14	3.00
I have helped implement lasting changes to district policies based on the team's strategic plan.	14	2.75	12	2.46	29	2.48
I have actively encouraged responsible risk taking on the part of teachers and other administrators related to implementing the strategic plan.	6	3.13	4	3.28	6	3.34
I have actively encouraged teachers to use NASA educational products in their classrooms.	0	3.66	0	3.38	4	3.61
I have supported teacher attendance to professional development conferences and workshops.	3	3.63	4	3.50	2	3.71
I have actively been involved with family events organized at my school.	0	3.47	0	3.28	2	3.42

	2003		2004		2005	
	(%) No	(mean) Yes	(%) No	(mean) Yes	(%) No	(mean) Yes
I have provided teacher release time to help the NASA Explorer School team members implement their strategic plan.	8	3.44	8	3.18	6	3.36

Outcome 1
Participation and Professional Growth of Educators in Science

<u>Guideline 6. Teachers/Administrators Demonstrate that NES Interventions Are Connected to School Reform</u>

Successful implementation of the NES intervention is best measured through evidence that reform strategies are connected to curriculum reform adopted at the school and district level (Committee on Science and Learning through Eighth Grade, 2007). The NES project is designed to link with school reforms that promote (1) teacher professional growth in STEM areas that has a schoolwide focus, (2) curriculum design (especially in STEM areas) strategies that are consistent with NES focus on increased use of inquiry and improved classroom management practices, (3) improving school climate by offering increased out-of-school STEM enrichment activities that stimulate student interest in STEM topics and careers, (4) efforts to improve relationships with feeder schools and community, and (5) leveraging NES funding to pursue additional partnerships (i.e., with local colleges and universities) and funding (See Table 5.15).

Table 5.15. Case Studies: Demonstrations That the NES Intervention Promotes School Reform

Successes	***Challenges***
I59 teamed up with faculty at a local university to plan sustainability.	B72 A & B: Problems with two schools: The B72-B school administrator was officially on the NES team and attended the orientation workshop. At B72-B in-service time is dedicated toward NASA-specific training. At B72-A the school administrator is an unofficial team member and did not attend the orientation workshop. At B72-A in-service time was not made available for NASA-specific training. As a rural, Appalachian school, some of the challenges the B72 A&B teams faced are documented in an article by Hobart and Seal (1995) that describe the cultural barriers that impede reform activities in some rural communities.

Successes	***Challenges***
J22 has established a partnership with Lockheed Martin.	H6: Professional development days promised by the school board were taken back. The team overcame this challenge by doing professional development during team meetings.
B72: Partnership with business helped team implement NES and increase family involvement.	G145 teachers have to find ways to make things work with the California state standards. Sometimes they need to adjust the NASA materials and resources to more closely match state guidelines.
C6 Received a grant from the University of Arizona.	I38 is a rural school and does not have a partner in education.
H6 developed partnerships with Coppin State University, U.S. Fish & Wildlife Service, Maryland & Chesapeake Bay Foundations, and “Adopt-a-Pilot” program of Southwest Airlines to teach STEM in creative and challenging ways.	
D109 received a 2007 Educator Grant from Air Force Association to promote aerospace education activities as well as a learning grant for an after-school tutoring and enrichment.	
B103: As a result of its participation in the NASA Explorer Schools program, the team was invited to participate in the 2006 Governor’s Summit on Science, Mathematics, and Technology Education.	
H6 has become a model of achievement for inner city public schools as a result of its strong leadership, committed teachers, and parental and community involvement.	
A42 received a $1.7 million grant from Magnet Schools of America to help facilitate its math, science, and technology lab. In the 2005-2006 academic year A42 received two awards, one recognizing the achievements of the school’s volunteer program, the other providing support for continued student participation in STEM competitions and faculty professional development in STEM areas.	
I59 teamed up with faculty at a local university to plan sustainability.	

Successes	***Challenges***
J22 has established a partnership with Lockheed Martin.	
B1 has been successful in building a collaborative relationship with its state Space Grant Consortium and has built working relationships with other K-12 and postsecondary science educators through the Space Grant connection.	
F59 leveraged its NES funding and established a partnership with the Space Grant Consortium.	
E57 is not only taking advantages of the instructional supports for teachers from NES, but also leadership support for the administrator. The involvement of an administrator on the curriculum side has made the implementation processes easy.	
J71 found that the partnership with NASA has brought tremendous publicity to the schools. It has made it easier for the schools to get other grants. For example, one of the schools was awarded two National Science Foundation grants, and the other two schools were awarded Botball grants.	
I16 has successfully leveraged its NES partnership to apply for additional grants (Pratt and Whitney Rocketdyne grant).	
A104 has a partnership with local business to support its students' participation in the robotics competition.	
D143 has engaged the community (fire department, district personnel, Northrop Grumman, and a member of Congress) through its NES activities. Its activities have been reported on the radio, television and in its local Spanish newspaper.	
D106 educators have sought out opportunities offered at the local university and continue to build scholarly activities with the university.	

Successes	***Challenges***
C103 received other grants, including a Convergence Ed Foundation—Tech Rich Ed for Kids grant, which provided support for an after-school ham radio club, an Air Force Association grant for building model rockets, and a 21st Century Award.	
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 sixth-graders.	

Findings from Survey Data

Administrator support for NES sustainability. In all of the 12 areas listed in Table 5.16, findings indicate that administrator support increases cumulatively each year of the NES implementation. More than two-thirds of the administrators of the 2003 team reported seeking external support on behalf of the NES team from local and distant sources, with the exception of one item encouraging "collaboration with international schools." Overall, three items that involve seeking local support from the district leaders, superintendent, and board leaders and two collaboration items (encouraging collaboration with the other schools in the district and other distant NES schools) are reported to be at and above a 3-point average for the 2003 team.

Table 5.16. External Support Administrators Sought on Behalf of the NES Team at School

	2003		2004		2005	
	(%) No	(mean) Yes	(%) No	(mean) Yes	(%) No	(mean) Yes
I have encouraged the district leaders to maintain an interest in our efforts with the implementation of the NES program.	6	3.38	4	3.14	4	3.04
I have encouraged the superintendent to maintain an interest in our efforts with the implementation of the NES program.	14	3.16	10	3.06	10	2.89
I have encouraged the school board leaders to maintain an interest in our efforts with the implementation of the NES program.	19	3.02	12	2.94	14	2.91
I have encouraged collaboration with other schools in the district to share the gains of the NASA Explorer Schools program.	3	3.30	10	2.78	14	2.67
I have encouraged collaboration with other NASA Explorer Schools.	17	3.05	18	2.32	25	2.36
I have encouraged collaboration with non-NASA Explorer schools outside of our district to share gains of the NES program.	20	2.91	36	2.18	37	2.12

	2003		2004		2005	
	(%) No	(mean) Yes	(%) No	(mean) Yes	(%) No	(mean) Yes
I have sought additional funding from the district to supplement the funds provided by the partnership with NASA.	14	2.97	29	2.42	16	2.73
I have sought funding from some of the businesses in the community.	22	2.83	28	2.30	27	2.24
I have sought personnel support from some of the businesses in the community	31	2.52	30	2.16	30	2.21
I have sought personnel support from some of the universities in the community.	28	2.55	40	2.10	32	2.12

Outcome 2
Assistance for and Technology Use by Schools with High Populations of Underserved Students

Guideline 1. Technology Funding to Support NES Implementation at Underserved Schools

NASA Explorer Schools get funding to purchase software and hardware that supports school implementation of the NES project and serves students who qualify for either (or both) Title 1 funding or assistance with English language learning. The more successful schools are able to leverage NES funding for technology purchases with supplemental funding and make appropriate instructional modifications so that the technology purchased is integrated with school goals for STEM improvement (see Table 5.17).

Table 5.17. Case Studies: Technology Funding to Support NES Implementation at Undeserved Schools

Successes	***Challenges***
C14 found an innovative use for the distance learning equipment purchased with its NASA grant. It was able to help a student who broke his leg by connecting the classroom to the student's home. This use of videoconferencing equipment encouraged teachers to become familiar with using the distance learning equipment. They now appear to be more comfortable using it.	J22 reported that late funding was a challenge because "we were going to take pictures of activities, and we had to share a camera. Then in good faith the district bought the videoconferencing equipment, and we had no idea of when the $10,000 was coming. We are a little wary of next year. We have plans for robotics for next year, and we do not want to say much to the kids or the parents about it because we may not be able to do it."
C103: The technological tools the school purchased through NES have been a great help on the family nights.	B72 was not able to implement its technology plans because of the delay in receiving NES funding.
	A42 saw increases in the percentage of students who qualify for either a free or

Successes	***Challenges***
	reduced lunch because of low socioeconomic status (the percentage of students qualifying at A42 is 95 percent—the district average is 47 percent). About one-tenth of students have been identified as homeless.
	B1 has found that since the expansion in 2004-2005 involved at least a 40 percent change in population due to boundary or organizational change, the school did not receive a school rating this year.
	E25 was unable to purchase videoconferencing equipment due to funds coming late. It missed an opportunity to do a StormE simulation. It also couldn't buy materials for weekly clubs. These problems were resolved when funding arrived.
	F18 reported that the late arrival of NES funding caused problems in the school's ability to implement its NES plans. F18 needs more funding than what is available for it.
	G145 found that funding sometimes became a barrier. For example, a program that involved job-shadowing scientists got bogged down in how people were going to charge their shadowing time.
	D143 reported that late receipt of NES funds delayed the purchase of videoconferencing equipment and the use of the Digital Learning Network (DLN), which was one of the major goals of the D143 NES team.
	I38 describes that late funding was an issue because it delayed the purchase of videoconferencing equipment and use of DLN programs that are important because of I38's rural location.
	D106 explains that the late arrival of the NES funding both from NASA and from the district caused some problems in the school's ability to implement its NES plans. The first-year funding was a year late, and the second-year funding was half a year late.

Administrator Attitudes Toward Technology to Support NES Technology Integration

Table 5.18 presents the percentage of administrator agreement and disagreement with the statements related to their attitudes toward technology. Overall, the 2003 and 2005 administrators' attitudes are found extremely positive as observed by their 100 percent agreement with many of the statements listed.

Administrators from the 2004 cohort, however, do not seem to be as at ease with technology. A greater percentage of 2004 administrators (14 percent compared to 3 percent by 2003 and 2005 administrators) feel tense when people start talking about technology and feel pressured from others to have teachers use technology in the classroom (26 percent compared to 19 percent). A greater number of 2004 administrators also believe that technology furthers the gap between students along socioeconomic lines (38 percent from 2004 cohort compared to 28 percent from 2003 and 2005). The 2004 administrators also think that technology makes high demands on their professional time (34 percent compared to 20 percent from 2003 and 2005 cohorts). Finally, fewer administrators from the 2004 cohort (55 percent compared to 62 percent from 2003 and 2005) reported that they help others solve technology problems.

Table 5.18. Percentage of Attitude Scores for Each Item

	2003		**2004**		**2005**	
	No	Yes	No	Yes	No	Yes
I would like every student in every classroom to have access to technology.	-	97	-	96	-	100
Technology skills are essential to students.	-	97	-	98	-	100
I feel tense when people start talking about technology.	89	3	80	14	89	3
I feel pressure from others to have teachers use technology in classroom.	58	19	60	26	58	19
I would like all our students to be able to use technology more.	-	97	2	92	-	97
Technology is dehumanizing.	94	-	88	2	94	-
I avoid technology whenever possible.	97	3	88	4	97	3
Technology is just another fad.	100	-	98	-	100	-
The use of technology should be confined to technology courses.	91	6	96	2	92	4
I like using technology to solve complex problems.	6	84	12	80	6	89
More training would increase my use of the technology at work.	11	83	-	88	11	83
The use of technology diminishes my role as an administrator.	97	3	92	2	97	3
Technology should be incorporated into the classroom curriculum.	-	100	-	98	-	100
Technology makes my job easier.	3	90	2	90	3	90

	2003		2004		2005	
	No	Yes	No	Yes	No	Yes
Technology furthers the gap between students along socioeconomic lines.	58	28	38	38	58	28
Technology skills help me as a professional.	3	94	2	98	3	95
Learning to use technology makes high demands on my professional time.	57	20	42	34	57	20
The use of technology changes my role as an administrator.	29	51	20	56	27	53
I can help others solve technology problems.	14	62	16	55	14	62
The use of technology enhances classroom instruction.	-	100	2	96	-	100
Technology is worth the time it takes to learn it.	-	100	-	98	-	100
I have observed that students are more motivated when they use technology.	-	100	2	88	-	100
Technologies such as handheld devices and digital cameras help inquiry learning.	-	100	-	88	-	100

Outcome 2
Assistance for and Technology Use by Schools with High Populations of Underserved Students

Guideline 2. Use of Technology Tools to Support STEM and Language Arts Instruction

This criterion looks for evidence of teachers using the following technology tools to support STEM, reading, and language art curriculum as well as participation in NASA Digital Learning Network activities at the school (see Table 5.19).

Table 5.19. Case Studies: Use of Technology Tools to Support STEM and Language Arts Instruction

Successes	***Challenges***
J22 has successfully documented its NES implementation and is considered a model school for best NES e-Folio. DLN was integrated into the J22 curriculum to spark student interest and put them in touch with NASA staff and exciting technology.	D109: The entire school did not have the same access to types of technology. For example, NASA resources are very limited for grades K-3, and the technology support is inconsistent across grade levels.
C6: Since becoming an NES school, teachers have trained to become familiar with science content and different technology tools to promote students' learning.	A42 explains that reported incidents of violence at the school affect the overall school climate.

Successes	***Challenges***
B72 uses e-mail and has plans to use videoconferencing equipment to facilitate communication.	B1 suffered from a lack of on-site technical support and instructional technology training that would let the school take advantage of its technology enhancements to link with NASA curriculum resources.
A126 established an after-school science club that included activities requiring use of a variety of technologies.	J71 encountered a technical problem that needed an on-site technician to fix the problem. The malfunction of videoconferencing equipment caused delays in the implementation process.
I16 has increased student access to instructional computers with Internet access.	A104 notes that late funding caused delays in holding a family night focused around telescopes because the NES funding was slated to purchase telescopes.
I38 purchased technology tools, teachers received professional development on how to use the technology, and students in turn benefited either from classroom use or hands-on use of the technology provided via the NES project. NASA materials and especially use of the Digital Learning Network (DLN) were integrated into classrooms.	G110 reported that the delay in receipt of NES funding led the team to put off some technology implementation for its students. Teacher buy-in has been a challenge. Teachers have a hard time thinking about how they are going to implement NASA resources in their classroom with some of the curriculum challenges that they have to address. The G110 NES team expects the Digital Learning Network activities to provide a solution for this problem.
J65 reported that the innovative technologies for learning have changed how teachers teach and think about how people learn.	I38 experienced technology problems with the firewall in its computer system.

Outcome 2
Assistance for and Technology Use by Schools with High Populations of Underserved Students

<u>Guideline 3. Teacher Reports Regarding Frequency of Using Technology</u>

In this category the researchers looked for evidence that the link to STEM-G content is clear. Table 5.20 lists teachers reporting the frequency of using the technology in a STEM context.

Table 5.20. Case Studies: Teacher Reports Regarding Frequency of Using Technology

Successes	***Challenges***
The D109 partnership with NES has allowed teachers to attend videoconferencing equipment training so	B72 found it a challenge to find time to train teachers to use new technology as well as address the varying comfort levels

that they can integrate more DLN programs into the curriculum.	of teachers with technology.
F59 reported increasing numbers of students, families, team members, and non-NES teacher participating in DLN activities.	*C103* reported that unresolved technical problems and lack of on-site technical support have inhibited progress according to schedule.

Outcome 2
Assistance for and Technology Use by Schools with High Populations of Underserved Students

Guideline 4. Teacher Use of Technology in Their Preparations for Teaching
In this category teachers report on their frequency of using the technological tools in preparation for teaching or other professional activities and discuss their attitudes toward technology. Only two of the case study schools reported on this item in Table 5.21.

Table 5.21. Teacher Use of Technology in Their Preparation for Teaching

Successes	***Challenges***
C6 teachers have trained to become familiar with science content and different technology tools to promote students' learning since becoming an NES school.	H6 teachers discussed their difficulties with having only two computer labs, which limited their ability to take the online surveys. Teachers completed some of the surveys outside of school hours.

Teachers' Teaching, Learning and Computing Perception Change After Participating in the NES Project

In this section we report on major findings from teachers' Teaching, Learning, and Computing surveys. We were able to match pretest and posttest data from 116 teachers in the 2003 cohort and 103 teachers in the 2004 cohort. Teachers in the 2005 cohort took only the posttest.

Paired-sample t-tests

Table 5.22 displays the results of paired-sample t-tests on 2003 and 2004 cohorts. The results show significant differences from pre-TLC to post-TLC in three of the five constructs: technical skills, attitude toward technology, and constructivist use of technology. The attitude toward technology use has significantly increased as the result of NES professional development. The mean scores went from 2.86 to 2.93. Although the analysis of paired t-tests also showed significant changes in teachers' technical skills and constructivist use of technology, the mean scores dropped from pre to post. Teachers' technical skills dropped from 2.87 to 2.70, and teachers' constructivist use of technology dropped from 2.47 to 2.12. This has implications on how the program should improve itself to enhance teachers' technical skills as well as their constructivist use of technology. Perhaps the program should focus on making the technology personalized to the needs of teachers and encourage their use of technology with constructivist teaching strategy. The connection between choosing certain technology and actually using it effectively in the classroom should be taught explicitly to teachers.

Table 5.22. Paired Samples Descriptive Statistics

	Pre-0 Post-1	Mean	Std. Deviation
Constructivist Teaching Philosophy	0	3.24	.26
	1	3.28	.30
Constructivist Teaching Strategies	0	2.78	.49
	1	2.71	.48
Technical Skills*	0	2.87	.42
	1	2.70	.48
Attitude toward Technology**	0	2.86	.29
	1	2.93	.40
Constructivist Use of Technology*	0	2.47	.65
	1	2.12	.52

*p<.001; **p<.05

Analysis of Variance (ANOVA)

Table 5.23 shows the results from the comparison of three cohorts in terms of teachers' Teaching, Learning, and Computing Surveys. A significant change was observed among cohorts to one construct—attitude toward technology. The post hoc test showed the 2003 cohort reported significantly higher scores than teachers in the 2004 cohort. There are no significant differences between the 2003 and 2005 cohorts or the 2004 and 2005 cohorts. The result implied an important message about how the program was started and implemented in the different cohorts.

Table 5.23. Descriptive Statistics

	Cohort	Mean	Std. Deviation
Constructivist Teaching Philosophy	2003	3.30	.30
	2004	3.25	.29
	2005	3.32	.30
Constructivist Teaching Strategies	2003	2.75	.52
	2004	2.69	.44
	2005	2.74	.50
Technical Skills	2003	2.73	.46
	2004	2.65	.49
	2005	2.63	.45
Attitude Toward Technology*	2003	2.99	.41
	2004	2.86	.37
	2005	2.96	.37
Constructivist Use of Technology	2003	2.18	.53
	2004	2.05	.51
	2005	2.03	.56

*p<.05

Pearson Correlation
Table 5.24 shows the results of pre-TLC and post-TLC correlation comparison. Teachers' constructivist use of technology is significantly and positively correlated with constructivist teaching strategy, technical skills, and attitude toward technology.

Table 5.24. Correlations

	CTP	CTS	TS	ATT	CUT
CTP	1				
CTS	.069	1			
TS	.077	.343**	1		
ATT	.069	.210**	.151**	1	
CUT	.164**	.656**	.551**	.211**	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Multiple regression. Multiple regression analysis was carried out to investigate the causal relationships within teachers' Teaching, Learning, and Computing surveys.

Figure 5.02 displays the NES standard regression coefficients in the context of the evaluation framework. For the NES project constructivist teaching strategy (52 percent), technical skills (37 percent), and constructivist teaching philosophy (10 percent) were stronger predictors of constructivist uses of technology after the workshop.

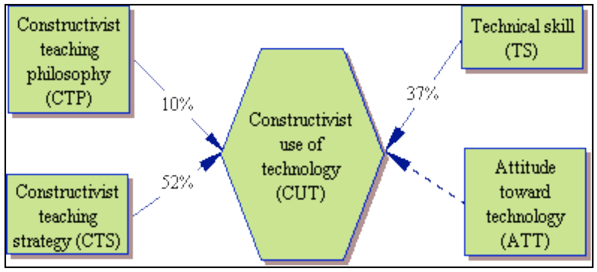

Figure 5.02. Graphic illustrates NES regression modeling. Note that dashed lines indicate path coefficients were not significant.

Outcome 3
Family Involvement in Children's Learning

For this outcome researchers look for evidence regarding strategies, activities, and targeted communications that teachers report using to increase parental involvement in students' learning—especially in the STEM areas. Specific strategies that have been encouraged and used as exemplary family involvement activities include NASA-sponsored family events offered at NES schools or community facilities, newsletters and other communications for caregivers that keeps them informed of NES project and STEM activities at the school, and other school-based academic enrichment efforts that are observed to have a positive impact on overall school climate and community value of STEM content and careers.

Several of the NASA Explorer Schools identified a member of their team who would serve as the family involvement coordinator and take the lead on organizing and coordinating activities and strategies to more effectively involve parents (primary caregivers) and community businesses and organizations in student learning—especially in STEM areas. Table 5.25 provides a summary of strategies that NES teams used to address their family involvement goals. Here is an example of how one school initiated administrative and structural changes in staffing to address family involvement issues:

> NES D143: "One of the ways we kind of tackled the issues of parents is we have a community liaison on our campus. She interacts with all the parents because we have 1,200 students at our campus, so she interacts with a majority of them, and she's instrumental in speaking to them during our monthly meetings about the NASA program or activities that are going on. She does a phone call, which is called a "Connect Ed." It's a system in which we are able to contact all of the parents and give them messages. Just recently, it's funny you said that, this past Saturday she took a group of parents to [FIELD CENTER D] to open house. That was a nice way to expose some of our parents and some of the children to, you know, this whole NASA, [FIELD CENTER D] relationship that we have" (Focus Group Interview, May 24, 2006).

Table 5.25. Case Studies: Family Involvement in Children's Learning

Successes	***Challenges***
D109 successfully carried out special events encouraging parental involvement, including family astronomy and science nights.	D109 found that use of the money is limited in terms of materials that teachers can purchase for parents nights.
C103: The technological tools the school purchased through NES have been a great help on the family nights.	H6 parents helped with fundraising to compensate for late arrival of NES funds.
B72 aligned activities to accomplish Title I family math science nights, which supported NES integration schoolwide partnership with local business helped NES and also increased family community involvement.	E57 has a hard time getting parents involved. Team members said the reasons might be either not getting the word out effectively or not developing programs that are really meaningful for the parents and families to interact with the students regarding NES activities.
B1 has found ways to keep local media informed of special events and accomplishments as they have occurred at the school, and the media has cooperated in helping to promote NES activities at the school to the community. The publicity has helped support community and family involvement goals.	G145: Population changes in the area surrounding the school impact the school student and family participation. Parental involvement is very difficult because some parents live 30-40 minutes from the school. The ethnicity of the school population is changing, and there has been a large teacher turnover in the past two years. Of 40 teachers, 17 are new. The school district is opening many "portable schools" in the region to address the changing population. School enrollment is increasing so fast that the sixth grade is moving back into the elementary school.
E57 found ways to increase community involvement through the media.	J71 found that getting the community involved and willing to sponsor events in the schools has been difficult. NASA should be more responsive than just providing the school resources. The needs of the schools should be the priority more than anything else.
A126 administrator said NES has helped the school increase student and parent attendance at school activities.	*D106* explains that it is hard to evaluate the impact of the program on students' parents because English is not the first language for most of the parents. Teachers found that their evaluation was limited to tracking attendance at events like the star parties that have been initiated at the school.

Successes	***Challenges***
I16 has increased family involvement through family science nights and home interactions and has built career awareness into its family science nights.	
A104 parents have credited many school successes to teachers' teaching quality and countless activities for students and family involvement, such as School of Aerospace Technology, Moon Math Challenge, FIRST Robotics, and a NASA science night/family science night.	
D143 found a strategy to work around the low level of parent education and lack of home computers—which was a limiting factor—by having a community liaison on campus who interacts with all of the parents. The community liaison speaks to parents during their monthly meetings about the NASA program and about current activities. She uses the "Connect Ed" telephone system to contact the parents and give them messages. She has taken a group of parents to a NASA field center [D] open house.	
D143 has shared NES resources and opportunities with D143 families as well as with regional educators.	
F59 family and community involvement increased.	
G110 received useful resources from NASA for its students and families during special events and activities. The parents of G110 students have actively participated in school activities, and participation has increased over time.	

Discussion of Previous Findings Based on Team Lead, Teacher Involvement, Workshop Surveys and Family Involvement Survey Report

Here are the research questions regarding the role of family involvement in STEM education:
- How was family involvement being addressed when the NES project started?
- How did the field center improve its support for family involvement?

Briefs 3 and 4 suggested family involvement was one of the critical factors for success. In the Administrator Survey the respondents expressed satisfaction in the family involvement (91 percent) that NES provided. They also believe schools will show increases in family involvement after three years in the program (80 percent to 90 percent). When administrators were asked to project NES' impact on family involvement at the end of the third year, 77 percent of the 44 administrators from 2003 and 87 percent of the 41 administrators from 2004 cohort expressed satisfaction with the emphasis on family involvement. In Team Lead Surveys with the 2003 cohort, the teachers commented that NES involvement improved family and community involvement and benefited the entire school community in gaining "recognition" and "a whole new feeling about the school" in the community. The community recognition helped school teams improve their image in the community. They were able to recruit more families for school activities as well as receive additional grant money because "parents can see new futures for their children, and they have a more positive view about what their children can accomplish and the contributions their children can make." Another benefit was the excitement of students and parents about the NASA program materials.

Family involvement has been addressed inconsistently across field center workshops—the most emphasis was on content knowledge (42 percent); the least on family involvement (11 percent). Three years into the project, field center staff recognized the impact of family involvement on students' learning. The students often present or assist with the activities on family nights, and their families' attendance supports their interest. In addition, family involvement has a large impact on student interest and career choices.

Some examples of family involvement events in orientation workshops were designed with daily themes, such as family involvement, flight, or the moon. Each activity was a piece of the conceptual puzzle for the participants. A thematic approach is one way to create coherence among activities by providing a context for each activity. Another approach is to prepare speakers to talk about their experiences and ideas for reaching out to families, or to give students extension activities to do at home with their families. For the family involvement events in content workshops with scientists as speakers and tours of NASA facilities, there are good opportunities to introduce NASA personnel with special attention to their career preparation and paths. Asking them to talk about how to involve families and how they involve their own children and families is one way to bring family involvement to the forefront.

Teacher Involvement Survey Data About Family Involvement

Teachers at NASA Explorer Schools were asked to report how family participation in NASA activities affected their students over the past year. Table 5.25 provided a summary of schoolwide teacher responses. In all five of the contexts listed, the pre-/posttest responses showed significant increases between fall 2005 and spring 2006. Table 5.26 which follows shows a statistically significant increase in teacher ratings of student behavior in all areas listed on family participation in NASA activities. Teachers perceive family involvement in NASA activities as having a positive impact on student involvement in after-school activities, performance in math and science, attitude toward school, and interest in STEM careers.

Table 5.26. Teacher Involvement Survey: Paired Samples Statistics

	Pretest mean (SD)	Posttest mean (SD)	N pre (n post)	Pre-/ posttest comparison (effect size)
STEM question: How do you think family participation in NASA activities has affected your students this year?				
More involved in after-school activities than before	2.76 (0.87)	2.92 (1.00)	330 (330)	↑ 0.004
Performing better in mathematics	2.69 (0.77)	2.96 (0.86)	328 (328)	↑ 0.000
Performing better in science	2.88 (0.79)	3.27 (0.84)	329 (329)	↑ 0.000 (0.001)
Attitude toward school has improved	2.98 (0.75)	3.23 (0.83)	332 (332)	↑ 0.000
More interested in STEM careers	2.96 (0.77)	3.11 (0.92)	327 (327)	↑ 0.005

Outcome 4
Student Interest and Participation in Science, Technology, Engineering, and Mathematics

This guideline examines what NES teams report that they have done within the context of their implementation of the NES intervention at their school to increase student interest in STEM-related disciplines including geography (See Table 5.27).

Table 5.27. Case Studies: Student Interest and Participation in STEM Areas

Successes	***Challenges***
H99 established a NASA Cadet program and local steering committee with the community college that student cadets attend for career-related enrichment activities, which include guest speakers.	B103 is working on school improvement issues that go beyond NES activities: What to do with half the students above the minimum competency who are getting bored? While NES may help address this issue, it cannot address all aspects of this school priority.
C6 has been encouraging students to do more nonfiction science reading to promote students' interest and participation in STEM.	B1 is taking steps to ensure equity in students' learning so that girls and boys are equally engaged and encouraged to pursue STEM topics and careers.
J71 schools have established after-school robotics clubs and participated in the FIRST LEGO League with the assistance of NES personnel and funding.	A104 students don't take the next step to get involved. The magnet school students don't' want to stay for after-school activities because they'll get home late, and

Successes	***Challenges***
	then they don't have time to do their homework or study, and their priority is to do well academically.
A126 initiated an after-school science club that successfully attracted students to participate in open-ended inquiry science learning. The club activities use a variety of technologies.	
F59 held after-school camps and successfully established robotics teams.	
H16 created a new NASA Science Club called the Ambassadors and a Beginner Invention Club to offer after-school activities for students interested in STEM.	
J65 students are excited about hands-on activities and participated actively in science inquiry.	

The Impact of Longitudinal Professional Development on Students' Interest and Participation in STEM, Knowledge About Careers in STEM, and Ability to Apply STEM Concepts and Skills in Meaningful Ways

As mentioned earlier, the NES program is unique in its targeted focus on underachieving schools as its primary audience. With this focus in mind, documentation of changes in student attitudes, interest, and confidence in STEM-related topics and careers is an important indicator of the NES intervention's success. The Student Interest Survey provided a way to register student self-ratings in six areas: (1) racial and ethnic background; (2) level of interest in STEM-related topics, processes, and careers; (3) perceived competence and self-concept in relation to school and STEM-related topics; (4) knowledge and perception of STEM concepts, topics, and careers; (5) family (community) involvement; and (6) knowledge of NASA and awareness of NASA.

Analysis of the pre/post Student Interest Survey data, is based on matching pre/post data of 580 students in grades 4-6 (representing 38 teachers) and 1,440 students in grades 7-9 (representing 16 schools). We summarize the findings along with tables[5] from student data in three sections: a) students' interest and participation in STEM, b) students' knowledge about careers in STEM, and c) students' ability to apply STEM concepts and skills in meaningful ways. Tables include only analyses for which there were pretest and posttest data.

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[5] [for all tables] For significant differences between mean scores, the arrow indicates the direction of the change, the next number is the level of statistical significance, and the number in parentheses is the effect size (Cohen). "N.S." indicates the difference between mean score was not statistically significant.

Student Interest and Participation in STEM

Tables 5.28 and 5.29 show the comparison of students liking the school subjects before and after NES participation. Statistically, we found that students in grades 4-6 and 7-9 showed significant increases in liking health/physical education and social studies/history. Although we did not observe significant changes on students' liking math or technology, the overall mean scores are well above average.

Table 5.28. NES Grades 4-6 Answering the Question on How Much They Like the Following Subjects

Items	Pretest mean (SD)	Posttest mean (SD)	Pre-/Posttest comparison (effect size)*
Art/Music/Drama	3.91 (0.68)	3.53 (0.48)	↓ .01 (0.65)
Math	3.95 (0.55)	3.74 (0.48)	N.S.
Health/Physical Education	3.82 (0.60)	4.14 (0.47)	↑ .01 (0.59)
Social Studies/History	2.61 (0.75)	2.96 (0.50)	↑ .05 (0.55)
Technology	3.70 (0.50)	3.67 (0.41)	N.S.

Note: The survey data is based on 580 matched 4-6th graders (representing 38 teachers).

Table 5.29. NES Grades 7-9 Answering the Question on How Much They Like the Following Subjects

Items	Pretest mean (SD)	Posttest mean (SD)	Pre-/Posttest comparison (effect size)
Art/Music/Drama	3.40 (0.41)	3.47 (0.40)	N.S.
Math	3.46 (0.53)	3.12 (0.43)	N.S.
Health/Physical Education	3.63 (0.44)	3.98 (0.35)	↑ .05 (0.88)
Social Studies/History	2.51 (0.27)	3.03 (0.45)	↑ .001 (1.40)
Technology	3.37 (0.30)	3.51 (0.31)	N.S.
Language Arts (Reading and Writing)	3.82 (0.29)	3.51 (0.31)	↓ .01 (1.38)

Note: The survey data is based on 1440 matched 7-9th graders (representing 16 schools).

Table 5.30 shows that grade 7-9 ratings regarding how much students liked doing some of the STEM-related activities significantly decreased. We conjecture that students' anticipation of these activities differed between the pre- and posttests, and that is why their ratings decreased. The decreased ratings reported in Table 5.30 also suggest that doing the activities in and of themselves is less interesting than using computers to investigate scientific topics, because Table 5.31 shows that students like using computers with science data. This finding suggests that the supports provided by NES for technology-based learning have an important impact on how students like using computers with science data.

Table 5.30. NES Grades 7-9 Answering the Questions on How Much They Like the Following STEM-related Topics or Activities

Items	Pretest mean (SD)	Grades 7-9 posttest mean (SD)	Pre-/Posttest comparison (effect size)
Conducting observations and measurements	2.91 (0.28)	2.73 (0.26)	N.S.
Learning about the motion of a vehicle	3.53 (0.34)	2.85 (0.26)	↓ .001 (2.24)
Finding patterns and relationships in data	3.07 (0.31)	2.68 (0.32)	↓ .001 (1.24)
Studying how energy is made	3.09 (0.41)	2.73 (0.21)	↓ .001 (1.10)
Using computers with science data	3.42 (0.33)	3.48 (0.34)	N.S.
Plotting locations	3.18 (0.39)	2.97 (0.38)	N.S.
Using math in science	3.25 (0.37)	2.80 (0.37)	↓ .01 (1.22)

Note: The survey data is based on 1440 matched 7-9th graders (representing 16 schools).

The results from correlation analysis (Table 5.31) show that students' ratings of use of NASA materials correlate positively and often significantly with desired NES project outcomes: liking science-related classes, developing science-related skills, using science-related skills. The table also shows the positive impact of teachers' use of NASA materials on their students. Positive impacts include students' liking the STEM-related subjects, increased self-confidence in using computers with science data, and increased self-confidence at doing scientific inquiry activities.

Table 5.31. Statistically Significant Correlations Between Students' Rating of Use of NASA Materials in Classes and Other Science- and Math-related Variables[6]

"How often do you or your teachers use NASA materials in geography?" (.372**) How much I like math (.409**) How much I like science (.315*) How good I am at using computers with science data (.312*) How good I am at using math to explore solutions to problems (.646**) How often as an adult I think I will use science to interpret news stories (grades 7-9 only)
"How often do you or your teachers use NASA materials in science?" (.369**) How much I like geography (.481**) How much I like science (.331*) How good I am at using computers with science data (.406**) How good I am at presenting the results of an investigation or project to the class
"How often do you or your teachers use NASA materials in technology education?" (.418**) How much I like geography (.521**) How much I like science (.426**) How much I know about technology education or engineering (grades 7-9 only) (.334*) How good I am at using computers with science data (.313*) How good I am at using math to explore solutions to problems (.569**) How good I am at presenting the results of an investigation or project to the class

[6] Correlations between NASA materials' use ratings and other variables are in parentheses. One asterisk (*) indicates statistical significance (two-tailed test) at the 0.05 level; two asterisks (**) indicate statistical significance (two-tailed test) at the 0.01 level.

Student ratings of use of NASA materials correlate positively and often significantly with desired NES project outcomes of liking science-related classes, developing science-related skills, and using science-related skills.

"The students first learned about the basic principles of flight, then collaborated in small groups to design a glider and built on a shoebox base that would fly. They learned that the space shuttle glide/slope ratio is 1:1, so their goal was to build a glider that exceeded that ratio. First, students needed to learn about ratios in general and needed to learn about the glide/slope ratio specifically (the relationship between the height the glider was launched to the distance it traveled). They also studied the aspect ratio (width of wing to length of wing). The measurements we took tied in directly with our measurements standards, and the ratios, although not required in fifth grade, directly related to fractions standards. The class conducted a videoconference with a NASA scientist, learning the fundamentals of flight and the requirements of their DLN activity. They then launched into two months of research and experimentation, followed by their glider flight trials and data recording and analysis. Following their final flights and data analyses, they reported their findings to their NASA scientist and proudly displayed their gliders by videoconference."[7]

[7] Photograph and quote source: e-Folio, 2007.

Outcome 5
Student Knowledge About Careers in Science, Technology, Engineering, and Mathematics

Guideline 1. Student Knowledge About and Attitudes Toward Careers in STEM Areas

This construct investigates student knowledge about and attitudes toward STEM careers. We looked for evidence demonstrating changes in how students see themselves in terms of future careers (see Table 5.32). For example, do students see themselves as a potential NASA employee? Do Student Interest Survey scores show increased interest in STEM careers? Is there evidence of student engagement in peer sharing (or training) and sharing with parents? Are student presentations featured at family or community outreach events related to NES or other STEM learning?

Table 5.32. Student Knowledge About Careers in STEM Areas

Successes	***Challenges***
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.	
I16 established a STEM business partnership program to support both objectives of increasing student awareness of careers and opportunities for teacher professional development. I16 used NASA people resources, bringing Hispanic role models to excite their subgroup of Hispanic students about careers and STEM subjects. I16 has built career awareness into their family science nights and conducted a career fair to support this objective.	
E25 provided opportunities for students to interact with professionals in STEM-related career fields.	
E98 students responded to the Return to Flight exhibits with increased awareness and enthusiasm about science and space-related careers with NASA.	

Student Knowledge About Careers in STEM

For career choices grades 4-6 showed significant increases in liking the following jobs: computer specialist, doctor, and teacher (see Table 5.33). Grades 7-9 showed significant increases in liking the following jobs: computer specialist, doctor, and engineer (see

Table 5.33). This finding tells us that students in grades 7-9 become more aware of other STEM-related careers. For example, they will consider engineering for a career. We also interpret this finding as being influenced by students' exposure to technology use in the classroom or by their teachers.

Table 5.33. NES Grades 4-6 Answering Questions on How Much They Would Like to Have the Following Jobs

Items	Pretest mean (SD)	Grades 4-6 posttest mean (SD)	Pre-/Posttest comparison (effect size)
Astronaut	3.12 (0.64)	3.01 (0.63)	N.S.
Astronomer	3.58 (0.65)	2.65 (0.49)	↓ .001 (1.57)
Biologist	3.17 (0.68)	2.69 (0.51)	↓ .001 (0.97)
Computer specialist	2.63 (0.55)	3.14 (0.49)	↑ .001 (0.98)
Doctor	2.62 (0.72)	3.21 (0.54)	↑ .001 (0.93)
Firefighter	3.21 (0.81)	2.80 (0.42)	↓ .01 (0.64)
Geologist	3.04 (0.79)	2.52 (0.35)	↓ .001 (0.85)
Oceanographer	3.13 (0.72)	2.90 (0.53)	N.S.
Teacher	2.82 (0.51)	3.20 (0.46)	↑ .001 (0.78)
Engineer	2.96 (0.49)	3.16 (0.44)	N.S.

Note: The survey data is based on 580 matched students in grades 4-6 (representing 38 teachers).

Table 5.34. NES Grades 7-9 Answering Questions on How Much They Would Like to Have the Following Jobs

Items	Pretest mean (SD)	Grades 7-9 posttest mean (SD)	Pre-/Posttest comparison (effect size)
Aerospace engineer	2.56 (0.30)	2.43 (0.28)	N.S.
Astronaut	2.99 (0.33)	2.73 (0.26)	↓ .01 (0.88)
Astronomer	3.48 (0.21)	2.61 (0.33)	↓ .001 (3.14)
Biologist	3.04 (0.41)	2.62 (0.27)	↓ .01 (1.21)
Computer specialist	2.52 (0.33)	2.97 (0.29)	↑ .01 (1.45)
Doctor	2.31 (0.27)	3.18 (0.41)	↑ .001 (2.51)
Food scientist	2.43 (0.21)	2.55 (0.38)	N.S.
Geologist	2.70 (0.24)	2.46 (0.38)	N.S.
Meteorologist	2.43 (0.25)	2.45 (0.30)	N.S.
Oceanographer	2.81 (0.38)	2.73 (0.20)	N.S.
Physicist	3.29 (0.33)	2.62 (0.34)	↓ .001 (2.00)
Planetary scientist	2.38 (0.27)	2.51 (0.28)	N.S.
Teacher	2.63 (0.29)	2.72 (0.27)	N.S.
Engineer	2.79 (0.26)	3.17 (0.29)	↑ .001 (1.38)

Note: The survey data is based on 1,440 matched students in grades 7-9 (representing 16 schools).

Table 5.35 shows a significant increase in how grades 7-9 think they can use their math and science ability in a career, which is a very positive finding.

Table 5.35. NES Grades 7-9 Answering Questions on How They Think They Can Use Math or Science Ability in Their Careers

Items	Pretest mean (SD)	Grades 7-9 posttest mean (SD)	Pre-/Posttest comparison (effect size)
How successful do you think you would be in a career that required math ability?	2.47 (0.24)	3.33 (0.29)	↑ .001 (3.19)
How successful do you think you would be in a career that required scientific ability?	2.54 (0.29)	3.21 (0.36)	↑ .001 (2.05)

Note: The survey data is based on 1,440 matched students in grades 7-9 (representing 16 schools).

Students want to know: *How do they hold that International Space Station together?*

After the students sent nuts and bolts into space on the sounding rocket—and found out they came apart—the students wanted to know how they keep fasteners together in space. With the help of our NASA mentor, Jen Rochlis, experiments were designed to determine how gravity affects the way materials stay together in zero g.

One experiment has bars of Teflon that were torqued to specific levels. Then 1 pound, 5 pound, and 10 pound weights were attached during the zero g portion of the flight. They were also attached during the 2 g portions to determine the effects of hypergravity. The second experiment used student-created magnetic structures. The experiments were free-floated to determine the effects of both 0 g and 2 g. [Franke Park teachers discuss the students experiments conducted aboard the DC-9.][8]

[8] Source of photograph and quote: e-Folio (2007).

Outcome 6
Student Ability to Apply STEM Concepts and Skills in Meaningful Ways

Guidelines 1 and 2. Students Demonstrate and Use Scientific Explanations in Research and Problem-solving Contexts

In this category we looked for evidence that students understood and could use scientific explanations in STEM problem-solving contexts (see Table 5.36). Students' participation in STEM-related research projects and/or science competitions such as GLOBE, NES student research conference, and school science fairs were some of the criteria used as evidence. Teachers were also asked to share when their students received special recognition for achievement through review process.

Table 5.36. Case Studies: Students Demonstrate and Use Scientific Explanations

Successes	***Challenges***
C103 received a 21st Century Learning Grant for an after-school tutoring and enrichment program and also received a Convergence Education Foundation—Technology-rich Education for Kids grant, which provided support for an after-school ham radio club. They also received an Air Force Association grant to support student building, testing, and competing in model rockets.	*D106* teachers reported that the students in fifth grade had not been exposed to science or work at the level expected in fifth grade. As a result, teachers had to go back and teach some skills before they could do activities requiring higher-level skills.
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. They felt the students were better prepared this year and are optimistic that they will see an improvement in the math scores.	
E25 students were successfully engaged in interactive scientific research through GLOBE, ISS EarthKam Mission, CloudSat Network, and Winter's Story.	

Guideline 3. Student Achievement in STEM Areas

This outcome area examines teachers' perceptions of how well they think their students will do on achievement tests as well as examining actual annual yearly progress goals for NASA Explorer Schools. Teachers reported significant increases in student achievement scores that they observed, and they described the role that the NES project has played in theses changes.

Table 5.37. Student Achievement in STEM Areas

Successes	***Challenges***
I59 was on the list of poor performing schools two years ago. It is no longer on that list. Student reading and math achievement scores have improved significantly.	I16 teachers describe challenges to being able to address achievement gaps among subgroup populations.
C6 found that the number of students scoring below grade level dropped over the last three years from 78 percent to 39 percent. Teachers report that their involvement in the NES project is a contributing factor in student improvements in achievement tests.	
While B1 student achievement scores have improved, the improvement has been erratic and not sustained between yearly testing periods.	
J22 did not make its annual yearly progress goals in 2004-2005 but did in the last two academic years. The J22 team describes a gap between the test scores of white and black students in both math and English. In English the gap has diminished from 14 percent in 2004-2005 to 6 percent in 2005-2006. The gap in math scores has also diminished, moving from 23 percent in 2004-2005 to 8 percent in 2005-2006.	
D109 scores show that the percentage of students in the advanced category in mathematics increased from 2003 to 2006 for grades 2, 3, and 4. The percentage of D109 students in grades 1-5 scoring in the advanced category increased. A lower percentage of students in grades 2-3 scored in the far below basic standards from 2003-2006 as well.	
B103 student scores in state math, language, and reading achievement standardized examinations increased across all three categories.	
H6 student mathematics achievement scores at two grade levels exceeded state averages.	

Successes	***Challenges***
H99 observed improvements in reading, language arts, and mathematics during their three-year partnership with NASA. While H99 students have not matched state achievement scores, they have exceeded district averages in math for seventh and eighth grades in 2006.	
A42: While still working toward achieving the district average for math and reading on the Florida Comprehensive Assessment Test in reading and math, A42 student scores have increased substantially during the three-year NES program. For example, 7 percent of A42 fourth-graders in 2003 scored in the advanced achievement category in mathematics. In 2006 A42 had 23 percent of its fourth-graders scoring in the advanced range on the state math test.	
E57 student math and language arts annual achievement test scores have steadily improved during the three years of the NES project.	
G145 student math and language arts annual achievement test scores have steadily improved during the three years of the NES project.	
A104 has moved from not meeting AYP to provisional AYP in 2004-2005 year.	
E98 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 eighth grade math score increased from 23 percent to 40 percent, seventh grade math score increased from 12 percent to 19 percent, and sixth grade math score increased from 18 percent to 47 percent.	

Student Ability to Apply STEM Concepts and Skills in Meaningful Ways

Table 5.37 showed grades 4-6 students' perceptions toward level of difficulty in math and science significantly increased from pretest to posttest. Grades 4-6 students also perceived math and science subjects as harder for them compared to other school subjects. Although the data showed that grades 4-6 students showed significant increases in how math and science subjects are difficult for them, we have interpreted this as being a result of teachers' exposing students in grades 4-6 to science and some advanced math curriculum or activities and influencing these students to learn and experience real life science and math. From the case study analysis we learned that some of the schools did not have science curriculum before they started NES. Because of NES, schools received external resources for their science as well as math curriculum.

Table 5.38 shows that grades 7-9 students' perceptions toward level of difficulty in math and science decreased significantly from pretest to posttest. Grades 7-9 students also perceived that math was easier compared to other school subjects. The findings from Table 5.38 are consistent and complement the findings from Table 5.35 in that we know that grades 7-9 students think science and math subjects were not as hard as they thought they would be and they felt confidence in applying their science and math skills. Such findings are very encouraging and indicate that NES may have contributed to making STEM meaningful and accessible to the students.

Table 5.38. NES Grades 4-6 Students' Perceptions of How They Think of Math and Science Compared to Other Subjects and How They Will Do in Math and Science

Items	Pretest mean (SD)	Grades 4-6 posttest mean (SD)	Pre-/Posttest comparison (effect size)
How well do you think you will do in math this year?	3.85 (0.39)	3.90 (0.43)	N.S.
In general, how hard is science for you?	3.47 (0.63)	2.37 (0.32)	↓ .001 (2.20)
Compared to other school subjects…how hard is science for you?	3.49 (0.51)	2.56 (0.47)	↓ .001 (1.90)
In general, how hard is math for you?	3.43 (0.56)	2.20 (0.52)	↓ .001 (2.28)
Compared to other school subjects…how hard is math for you?	3.27 (0.61)	2.32 (0.54)	↓ .001 (1.65)
How much do you like conducting observations and measurements?	3.43 (0.52)	3.18 (0.44)	↓ .05 (0.52)

Note 1: The survey data is based on 580 matched students in grades 4-6 (representing 38 teachers).
Note 2: The score has been reversed (1 as very hard, 5 as not hard at all) on the questions of "In general, how hard is math for you?" "In general, how hard is science for you?" "Compared to other school subjects…how hard is math for you?" and "Compared to other school subjects…how hard is science for you?"

Table 5.39. NES Grades 7-9 Students' Perceptions of How They Think of Math and Science Compared to Other Subjects and How They Will Do in Math and Science

Items	Pretest mean (SD)	Grades 7-9 posttest mean (SD)	Pre-/Posttest comparison (effect size)
When taking a science test you have studied for, how well do you do?	3.80 (0.30)	3.65 (0.43)	N.S.
How well have you been doing in science this year?	3.82 (0.24)	3.59 (0.39)	↓ .05 (0.71)
How well do you think you will do in math this year?	3.64 (0.38)	3.53 (0.42)	N.S.
When taking a math test you have studied for, how well do you do?	3.38 (0.27)	3.53 (0.40)	N.S.
How well have you done in math in the past?	3.42 (0.22)	3.62 (0.30)	↑ .05 (0.76)
In general, how hard is science for you?	3.35 (0.31)	3.60 (0.29)	↑ .05 (0.83)
Compared to other school subjects…how hard is science for you?	3.33 (0.31)	3.51 (0.32)	N.S.
In general, how hard is math for you?	3.06 (0.21)	3.46 (0.33)	↑ .001 (1.02)
Compared to other school subjects…how hard is math for you?	2.87 (0.32)	3.40 (0.27)	↑ .001 (1.79)

Note 1: The survey data is based on 1,440 matched students in grades 7-9 (representing 16 schools).
Note 2: The score has been reversed (1 as very hard, 5 as not hard at all) on the questions of "In general, how hard is math for you?" "In general, how hard is science for you?" "Compared to other school subjects…how hard is math for you?" and "Compared to other school subjects…how hard is science for you?"

Table 5.39 shows that students in grades 7-9 significantly increased from pretest to posttest in how much they knew about health/physical education. Although no significant increase was found in how much they knew about math and science, their responses were well above average.

Table 5.40. NES Grades 7-9 Answering How Much They Know About the Following Subjects After NES Participation

Items	Pretest mean (SD)	Grades 7-9 posttest mean (SD)	Pre-/Posttest comparison (effect size)
Math	3.47 (0.31)	3.74 (0.37)	N.S.
Health/Physical Education	3.25 (0.38)	4.16 (0.25)	↑ .001 (2.83)
Science	3.72 (0.34)	3.58 (0.37)	N.S.
Social Studies/History	3.82 (0.37)	3.36 (0.38)	↓ .01 (1.23)

Note: The survey data is based on 1,440 matched students in grades 7-9 (representing 16 schools).

Tables 5.41 and 5.42 show very similar findings in that students in both grades 4-6 and 7-9 noted significant increases in how good they were at making observations and using computers with science data. We see this as a very positive impact of NES. Students have become good at making observations, which is one of the most important components of inquiry-based learning. We can infer that teachers are using more inquiry-based learning in the classroom, and this has made students feel comfortable and more confident. Data showing that students felt good at using computers with science data is also an important and encouraging finding because integration of technology in the curriculum has boosted students' confidence and skills with it.

Table 5.41. NES Grades 4-6 Answering How Good They Are at the Following STEM-related Activities

Items	Pretest mean (SD)	Grades 4-6 posttest mean (SD)	Pre-/Posttest comparison (effect size)
Developing a hypothesis	3.65 (0.54)	3.38 (0.41)	↓ .05 (0.56)
Making observations	3.39 (0.61)	3.68 (0.42)	↑ .05 (0.55)
Using computers with science data	3.52 (0.60)	3.92 (0.43)	↑ .001 (0.73)
Using math to explore solutions to problems	3.88 (0.54)	3.76 (0.47)	N.S.

Note: The survey data is based on 580 matched students in grades 4-6 (representing 38 teachers).

Table 5.42. NES Grades 7-9 Answering How Good They Are at the Following STEM-related Activities

Items	Pretest mean (SD)	Grades 7-9 posttest mean (SD)	Pre-/Posttest comparison (effect size)
Designing or planning an investigation or project	3.47 (0.31)	3.01 (0.26)	↓ .001 (1.61)
Developing a hypothesis	3.38 (0.26)	3.13 (0.23)	↓ .01 (1.02)
Testing a hypothesis	3.56 (0.33)	3.30 (0.29)	↓ .05 (0.84)
Making observations	3.11 (0.29)	3.39 (0.27)	↑ .01 (1.00)
Taking measurements	3.20 (0.37)	3.31 (0.21)	N.S.
Using computers with science data	3.09 (0.27)	3.53 (0.27)	↑ .001 (1.63)
Using math to explore solutions to problems	3.55 (0.27)	3.07 (0.27)	↓ .001 (1.78)

Note: The survey data is based on 1,440 matched students in grades 7-9 (representing 16 schools).

NES Student Achievement and School Report Card Achievement Test Scores

To measure a school's success, report card data were collected in math and reading (or language arts, when reading scores were not available), and difference in scores for both math and reading were computed. The higher the difference in scores, the more change was exhibited by the school. In particular, the percentage of students in a school that scored in the proficient or advanced ranges was calculated. Results were analyzed using a 2 (elementary or middle school) by 2 (math or reading scores) mixed design analysis of variance. Results showed an insignificant ($p = .526$) interaction, which suggests that the type of school has no effect on students' performance in math and reading (see Figure 5.03). This analysis suggests that modifying the NES program curriculum in order to strengthen math and reading skills in NES schools does not depend on the type of school. Even though the design and data collection were limited by differences in state-to-state assessment procedures, this comparison of student achievement score gains serves as a beginning model for measuring school success on a national level. Further research could involve comparing students' performance in relation to school demographics and location.

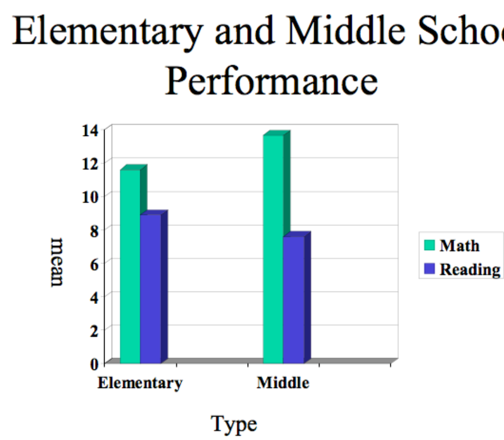


Figure 5.03 A summary of the 2 (elementary or middle school) x 2 (math or reading scores) mixed design analysis of variance, which showed no significant difference between type of school and achievement score gains.

Figure 5.04 presents NES schools meeting adequate yearly progress (AYP) before and after NES participation. AYP is a statewide accountability system mandated by the No Child Left Behind Act (NCLB) of 2001. It requires each state to ensure that all schools and districts make adequate yearly progress. AYP is a series of academic performance goals established for each school, local educational agency, and the state as a whole. States commit to the goals of NCLB by participating in Title 1, a program under NCLB that provides funding to help educate low-income children. The primary goal of Title 1 is for all students to be proficient in English language arts and mathematics, as determined by state assessments, by 2014 (Department of Education, 2007). All schools have the opportunity to appeal their AYP results. For example, schools can provide supporting documentation for substantive reasons, such as a natural disaster that prevented the local education agency from administering the applicable assessment or a significant medical emergency that prevented students from taking the originally scheduled state assessment(s).

Figure 5.04 illustrates the comparison of the first three cohort schools through 2006. The bar chart illustrates the trend across NES cohort schools for increases in student achievement scores and increased numbers of NES schools meeting their annual yearly progress goals. For example, the 2003 cohort had only 10 schools meeting AYP in 2002-2003 before they joined the NES project. After three years in NES, the number of schools meeting AYP increased to 22. We also observed that the numbers of schools becoming magnet schools increased. For example, by 2006 six schools in the 2003 cohort became magnet schools after three years of NES participation. This may imply being in the NES program encouraged schools to seek external support to sustain professional development and student learning.

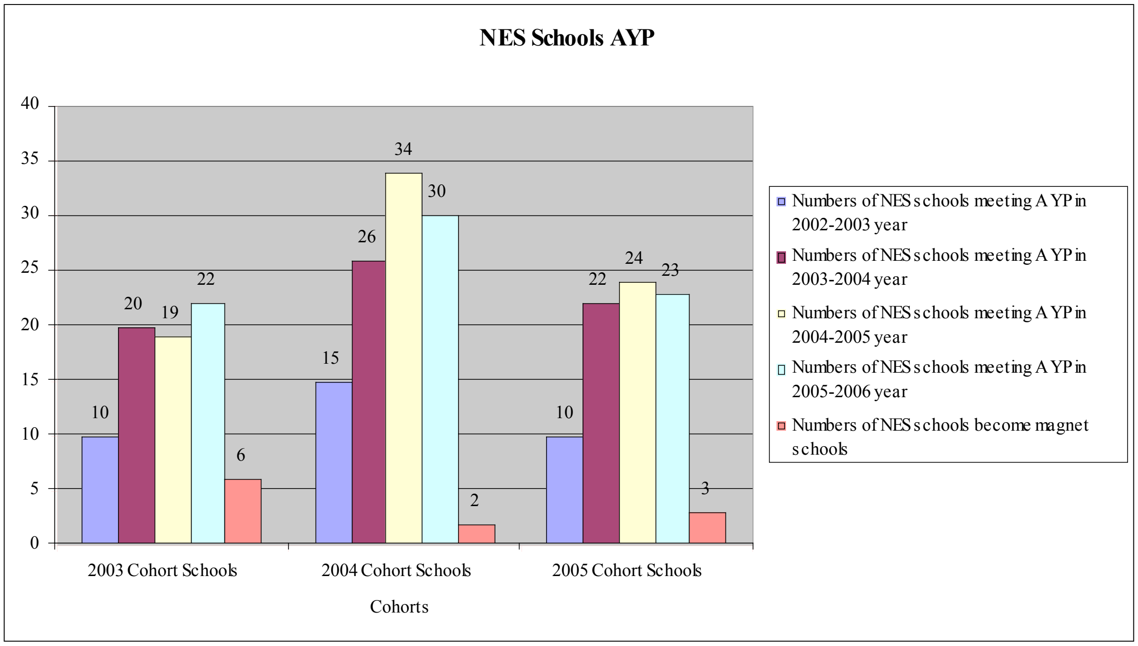


Figure 5.04. NES schools meeting AYP before and after NES participation.

School achievement of their AYP cannot be regarded as a direct result of the NES intervention because so many factors are involved in student achievement gains. In fact as the evidence for teacher growth in science education shows, most NES schools are involved in several curriculum reform intervention projects, of which NES is only one impacting teachers and students. However, the school improvements and student achievement scores tracked by the AYP accountability measures are important sources of indirect, circumstantial evidence that are used to understand and document school progress. Data collected from case study school interviews and teacher reports collected from surveys describe teacher observations of the links between NES activities and student achievement scores and teacher growth.

The blended method of analysis described in the Method section provides a way to build in-depth documentation of evidence that associates successful NES implementation with student achievement scores. The case study analysis provides detailed analysis of individual school environment links between NES implementation and school standards of learning goals. These data sources show how NES teachers and the administrator worked together to select and integrate NES activities and resources into their school curriculum. Successful schools most closely followed the theoretical model and showed evidence of implementing NES at the meets or exceeds expectations level on the NASA Explorer Schools Rubric (see Appendix).

Investigating Correlations Between Teacher, Technology, and Family Involvement Outcomes with Student Achievement

In the comparison of 2003, 2004, and 2005 case study schools, we found a significant correlation between professional development with teachers' use of technology, students' interest and participation toward STEM, students' knowledge about STEM careers, and students' abilities to apply STEM concepts in meaningful ways. We did not find any correlation between teacher professional development and family involvement (See Table 5.43).

The use of technology is highly correlated with students' knowledge about STEM careers and their ability to apply STEM concepts in meaningful ways but not correlated with students' interest and participation in STEM. Family involvement scores correlate with the use of technology by teachers and students' ability to apply STEM concepts in meaningful ways.

Our case study analysis confirms our quantitative data in that we found the following implications:

1. The NES teacher professional development affected how teachers use technology in the classroom and changed their students' interest and participation toward STEM topics, students' knowledge about STEM careers, and students' abilities to apply STEM concepts in meaningful ways.
2. Family involvement needs to be incorporated into teacher professional development.
3. The use of technology has an impact on students' knowledge about STEM careers and their ability to apply STEM concepts in meaningful ways.

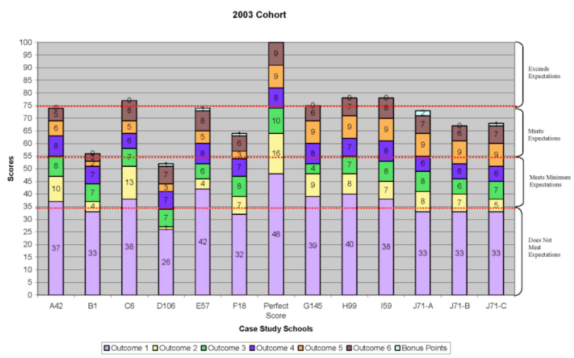
Table 5.43. Correlation Table

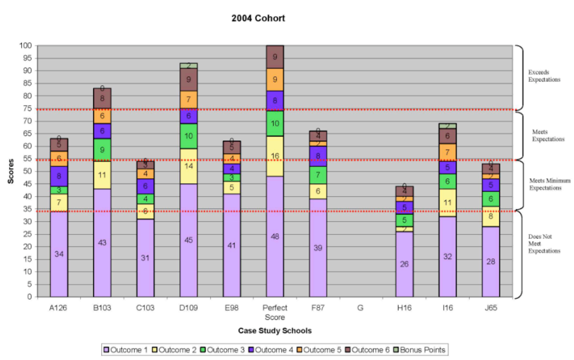
	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6
Outcome 1	1					
Outcome 2	.595**	1				
Outcome 3	.256	.417*	1			
Outcome 4	.364*	.116	.039	1		
Outcome 5	.383*	.372*	.011	.325	1	
Outcome 6	.444*	.387*	.364*	.266	.650*	1

** Correlation is significant at the 0.05 level (2-tailed).*
***Correlation is significant at the 0.01 level (2-tailed).*
Outcome 1: Participation and professional growth of educators in science
Outcome 2: Assistance for and technology use by educators in schools with high populations of underserved students
Outcome 3: Family involvement in children's learning
Outcome 4: Student interest and participation in STEM
Outcome 5: Student knowledge about careers in STEM
Outcome 6: Student ability to apply STEM concepts in meaningful ways

Frequency of Successful School-based Implementation of NES

The three charts below in Figure 5.05 provide a visual comparison of the rubric scores for each of the case study schools by cohort year.





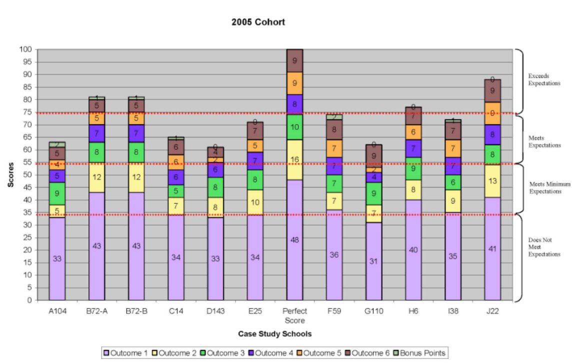


Figure 5.05. Summary charts of 2003, 2004, and 2005 case study school rubric scores.

The charts in Figure 5.05 show that all case study schools met at least minimum goals for implementation of the NES intervention. The charts show that the randomly selected case study schools reflect a breadth of implementation scores. Each year there are a few schools that exceed expectations. One school in the 2003 cohort and three schools in the 2004 cohort scored in the minimum category. In most cases the lower scoring schools in 2003 and 2004 had infrastructure problems that made implementation of NES extremely difficult. These problems are documented in the list of challenges presented earlier in the findings and can be matched by school code.

Across all three cohorts, 25 out of the 29 case study schools implemented the NES intervention to meet expectations of the NES rubric measuring achievement of the six anticipated outcomes. The color bars in the charts illustrate the areas of strength and weakness at each school. For example, while A104 scored a 34 out of a possible 46 on Outcome 1 (teacher growth), it received a rating of 9 out of 10 on Outcome 3 (family involvement).

The 2005 case study cohort scores show that none of these schools were in the minimum achievement category, and four scored in the exceeds expectations range. This may reflect that the school selection process was more rigorous. We also found that 2005 cohort postings to the e-Folio provided more data to support the case study analysis.

6. Discussion

The discussion extends the analysis by applying the findings to address the questions previously identified in the theoretical framework section. This section interprets the findings in terms of the impact of the NES program on schools, teachers, and students and implications for the future.

How Was the NES Project Evaluated from the NASA Field Center, School, Teacher, and Student Perspective?

A theory-based approach was used to evaluate the effectiveness of the NES project as a comprehensive STEM-related reform intervention. The evaluation involved a thorough examination of existing research on the relevance of NES goals, careful analysis of available data sources, and a strategic blending of quantitative and qualitative data. Use of the cluster-based, randomly selected case studies provided a means to document and investigate how the implementation was carried out at the school level.

How Were Field Centers Evaluated? Was the Effective Professional Development Provided Through Workshops Equally Distributed Among Field Centers?

Brief 4 (Davis, Palak, Martin, & Ruberg, 2006) summarized how the field centers implemented the NES project. The authors concluded that field centers disseminated NES through professional development and provided support on an individual basis for schools asking for help. In this report we analyze the teachers' responses regarding the effectiveness of the professional development they received through workshops. The data show that over the first three years of the NES project, field centers continued to improve and sustain the high quality of professional development. Teachers indicated that they highly valued how the workshops helped them grow personally and professionally. For example, by 2005 all field centers received above a 4.2 rating (out of 5) of overall workshop quality compared to a 3.7 rating in previous years.

How Did the Field Centers Address the NES Project Goals and Resolve the Problems Faced by Each School?

The NASA field center staff identified factors for success related to both NES schools and field centers (Brief 5, Ruberg, Martin, Chen, 2007). From the schools' perspective teachers found that scheduling field center staff was difficult, on-site professional development was tough and demanding for most of the teachers, teachers were unsure of what they wanted, and instability within the NES team made it difficult for the team to implement the NES project. The guidelines from the NES theoretical framework recommend assessment of schools' needs based on the content, context, and students. Completing an academic needs assessment is part of a school's application procedure, which is updated annually by the NES team. Unfortunately, the Teacher Involvement Survey showed that the school strategic and implementation plans, which articulate individual school goals and objectives, were not consistently used by NES coordinators and school teams.

Field centers faced different problems. They had a tight timeline for providing schools with information. They felt the need to increase the number of AES personnel for centers that served more schools or schools in more distant locations. Field center personnel also indicated that the selection process needed to be refined to better identify schools that were likely to benefit most from NES. The field centers also found it challenging to select appropriate NASA curriculum and to help schools align NASA materials with district and state curriculum requirements.

Brief 4 (Davis, Palak, Martin, & Ruberg, 2006) and Brief 5 (Ruberg, Martin, Chen, 2007) reported that field center staff and AES who work collaboratively and have a crisis or emergency team to manage problems faced by each NES school had the most impact on the schools. Field center staff and AES who helped NES teams foresee and address unexpected issues beforehand (team turnover, leadership change, lack of certified teachers, funding delay, on-site technical problems) and who provided intermediate or immediate support (team backup plan for turnover, training for leadership, backup plans for funding delays) for approaching unexpected issues were most likely to make the implementation transition easier and smoother for the NES team.

What Areas Did School Implementations (That Have at Least Met Program Expectations) Meet Theoretical Criteria?

The findings show that the NES intervention had a positive impact on participating schools, teachers, administrators, students, and their families. The measure of success varies based on school capacities, team and school commitment, school environment, and sustained NASA field center (or other STEM-related partner) support. Challenges that underachieving schools faced were not erased, but they did not preclude these schools from achieving significant areas of success. Schools that closely followed the guidelines of the theoretical framework showed the greatest achievements.

One area we believe is important to address in professional development is family involvement. NASA Explorer Schools already struggle with inconsistent family participation and the ongoing task of involving families in school activities. We believe NES should establish for field center staff specific guidelines for increasing family involvement. Understanding the theoretical framework and its underpinning perspectives would improve overall implementation and replication efforts to reinforce success in meeting NES goals.

How Unique Was Each Case Study Implementation?

The case study method is used to answer "how" and "why" questions in natural settings. Such analysis provides a holistic, in-depth understanding of the variety and value in each center's and schools' implementation of the NES model.

Ten case study schools were randomly selected, one from each field center in each of the NES project's first three cohorts (2003, 2004, and 2005). The case study evaluation draws largely on data from interviews with leadership teams, from quantitative items on the questionnaire survey relating to professional development, and qualitative open-ended questions. In the interview teachers had been asked about how the school teams work as a unit, how the teachers implement their school's strategic plan, what they perceive to be the impact of the program on themselves and their students, what are their evaluation plans, and what is their understanding of NES goals. The case study evaluation results reveal the interwoven nature of experience gained within a range of professional contexts, including classroom, school, district, and state. This case study report documents the evidence to show that the NES project has achieved success in each of its six objectives. Examples of how each case study achieved or overcame challenges are reported for each NES objective in this report.

What Impact Has Participation in NES Had on Teacher Use, Attitudes Toward, and Integration of Technology by Teachers?

From the case study analysis teachers made efforts to incorporate NASA materials for coherent STEM instruction and track the development of STEM learning objectives that align with state standards. The teachers increasingly blocked schedule days for STEM topics, used interdisciplinary study, and made STEM curriculum available to students. While the evidence showed that teachers adjusted their schedule to integrate more STEM topics in the curriculum, we found the frequency and accuracy of using inquiry-based strategies needs to be further addressed to the teachers. We suggest the workshop should allow teachers to digest and practice what they learn. The use of inquiry-based learning should be monitored in the school too.

The analysis of case studies shows that being in the NES project helped schools to take steps to leverage partnerships with other NES schools and other non-NES teachers. The level of commitment and participation in STEM increased as a result of increasing satisfaction with the professional development experiences, increasing conference opportunities for teachers, increasing numbers of special education and junior high teachers, and increasing supports from the field centers and AES. To promote enthusiasm for STEM topics schoolwide, teachers co-hosted on-site professional development with AES and established a NASA-rich environment by immersing space themes throughout the school. Team leads' satisfaction with support from field center staff slightly decreased from year to year because more attention is paid to the new NES schools brought in each year. Team leads' ratings of the benefits of NES participation increased significantly the longer a school was in the program. Although a majority of school administrators were concerned about the time it took teachers to implement the project and how overwhelming the project could be, administrators in all three cohorts were satisfied with the NES emphasis on teacher professional growth, student STEM learning, student STEM career interest, and family involvement.

The case study analysis shows that teachers were motivated to incorporate NASA materials in the classroom, and they aimed their teaching strategies toward improving not only STEM instruction, but English, reading, and language arts instruction as well. The NASA materials were also made available to K-6 students, and school curricula was restructured to meet NES goals and state standards. The teachers credited this movement to AES support on modeling inquiry activities for teachers and the AES' passion for science and education.

The results of case study analysis show that working closely with AES and field center staff helped teachers engage more deeply in science and integrate more inquiry activities. The teachers' confidence and comfort levels in teaching STEM topics increased. They showed significant increases in their comfort teaching science concepts, but their comfort in teaching educational technologies, engineering, technology education, robotics, and geography decreased from pretest to posttest. That lower comfort levels in teaching technology-related concepts might be associated with a lack of on-site technical support and technology skills.

The case study analysis provides evidence that developing a new curriculum map for STEM, meeting regularly with team members to plan and carry out STEM activities, having consistent NES team leadership and stability, and forming an effective team are essential to successfully align content gained through NES with learning standards. Team leads indicated that changes in team membership made the implementation process difficult. The support from school administrators was also instrumental to the overall implementation. Overall, administrator involvement with NES activities increased over time despite frequent administrator turnover in most NES schools.

As evidenced in the case study, schools that teamed up with local universities and partnered with local businesses to build family involvement showed prolonged sustainability. Some schools received additional grants besides NES funding. Building relationships with state Space Grant consortium was also a benefit of being a NASA Explorer School.

What Crosscutting Themes Are Evidenced by Highly Successful Schools?

Theme 1. NES intervention is a schoolwide implementation rather than a team effort. Some schools start with a small group of students and target a certain grade level; however, our case study analysis shows that most successful schools make NES part of a schoolwide intervention. These schools involve all grades and teachers, and they send messages to families about upcoming family nights to increase family participation.

Theme 2: Integration of teaching strategy is a team/collegial effort. Teams that develop a systematic/school-level plan for approaching and implementing teaching strategy are more likely to succeed and achieve NES goals.

Theme 3: Teams that make efforts to focus on motivational strategies for themselves and other non-NES teachers are more likely to receive greater benefits from NES. Examples of motivational strategies include using NASA publicity as an attention-getter or as part of a marketing plan to motivate other teachers and involve the community.

Theme 4: Teams that leverage NES funding to seek out support from others tend to target specific subject areas (such as robotics, rocketry, or air engineering) rather than for general STEM.

Theme 5: Reflective teaching practice is a key to successful teaching strategy implementation. Teams that indicate increased self-awareness and metacognitive reflection about their teaching are more likely to report increased satisfaction with content knowledge and teaching skills.

Theme 6: Teams' effective use of field center staff and AES is critical to teachers' content knowledge growth, schoolwide implementation support, alignment with state standards, and implementation of teaching strategies.

Theme 7: Teachers and students who make use of technology and are able to connect technology to daily life exhibit greater attitude changes toward technology.

Theme 8: Use of videoconferencing for instructional purposes is very effective. Technology has changed the way teachers teach and think about teaching.

What Crosscutting Themes Are Evidenced by the Least Successful Schools?

Theme 1: Facing technical problems (most frequently with videoconferencing equipment) influences teachers' tendencies to adopt and implement technology tools effectively. When teachers don't perceive either a technology's utility or their own ability to use it, teachers are less likely to include technology in their teaching practices.

Theme 2: The NES intervention cannot be implemented in a school environment that is unstable, undergoing restructuring, or does not have decision-making administrator support for teacher participation in NES.

How Did NES Teachers Change in Terms of Their Technology Use, Attitude Toward Technology, and Technology Skills?

NES teachers significantly changed their attitudes toward technology. Although the changes in teachers' technical skills and technology use decreased, it was not significant. Our interpretation for the finding is that teachers became aware of the complexity of new technology tools that they explored through NES, and they experienced a learning curve not only for learning new technology, but also for adapting it to their practices.

What Evidence Has the Evaluation Collected Regarding Goals for Student Interest and Achievement?

- Did the NES project increase students' interest and participation in the STEM-related subjects?

The integration of instruction in skills from weaker subjects into subjects where students were already highly engaged and learning rapidly was important for shortening the differences in performance. For example, teachers who sought out ways to match STEM activities with physical education had great potential for making science, math, and technology topics more accessible and interesting to a broader youth audience.

Examination of how technologies offered by NES influenced students' science learning revealed a statistically significant correlation between frequency of teacher use of NASA materials in science, geography, and technology education classes and students' liking and feeling good about using computers with science data and presenting the results of an investigation or project to the class. This result informed several positive outcomes involving technology use. This implies that technology has potential as a tool to engage students in authentic inquiry activities that lead to increased interest and confidence in science learning.

- Did the NES project increase students' interest, awareness, and knowledge about careers in STEM-related areas?

Our paired survey results for students in grades 4-6 and 7-9 showed that students' interest in STEM subjects was sustained and well above the average (2.5). In the students' interest in STEM activities, we found a decrease except in using computers with science data. Results from the correlation analysis showed strong relationships in teachers' use of NASA materials and in how much students like STEM-related subjects, and increases in students' self-confidence in using computers with science data and doing scientific inquiry activities.

Our findings indicated that grades 4-9 significantly liked and wanted jobs related to computers, such as computer specialist and engineer. They also showed increased self-efficacy in using math and science skills in their future jobs.

- Did the NES project increase students' ability and skills to apply STEM-related concepts and skills in meaningful ways?

Brief 5 (Ruberg, Martin, & Chen, 2007) included four reports that collected pre/post data regarding student abilities and skills to apply STEM concepts and skills. The DLN report showed both student and teacher gains from pre/post comparisons of test results associated with school participation in a series of DLN microgravity activities. The NES Challenge report showed gains in student language arts performance based on teacher review of student work. The University of Michigan NES Handheld User Community report showed gains in student achievement in several of the schools that integrated handheld technologies. This NES study suggested a relationship between teacher technology skills and duration of curriculum-based use of handheld technologies. The NES content tests also reported on in Brief 5 were designed to address the most frequently cited academic needs expressed by participating NES teams. The pilot testing of these content assessments did not show significant gains. The recommendation was made that content assessments be tied to particular NES curriculum activities so that pre-/posttests can be more closely linked to school-based instruction.

The school report card data was used as an indirect source to measure student achievement both before and over the course of participation in the NES project. As

Table 5.04 shows, the number of NASA Explorer Schools meeting AYP doubled for each of the cohort groups. While this measure cannot be represented as a direct result of NES, as explained in the findings, the gains in student achievement in high stakes testing are supported by the blended methods comparison that shows that schools that successfully implement the program (especially in addressing specific guidelines that are correlated with student achievement gains) will show gains in student performance on achievement tests.

How Effective Was the Grounded Theory Model as a Predictor of NES School Success?

The data summarized above shows that the grounded theory model has served as a useful tool for identifying successful implementation of the NES project. The qualitative data and cross-case analysis findings have been consistent with quantitative pre/post survey results. Most importantly, the theoretical model helped the evaluation team find areas where the NES intervention is most successful and where professional development support should be further refined and expanded. These areas are:

- Involving students in generating and evaluating scientific evidence.
- Helping teachers model scientific reasoning for students.
- Helping teachers recognize and change common student misconceptions.
- Helping teachers improve their pedagogical understanding of content so that they can document the impact of specific teaching strategies on student learning.
- Helping teachers work as a team to plan, review, and connect NES implementation to specific standards for student achievement.
- Preparing teachers so that they can integrate student use of technology within STEM content instruction at least twice a week.
- Supporting student participation in the scientific inquiry process.

7. Recommendations for Next Steps

Based on the findings and conclusions of the evaluation, what should be the next steps for an ongoing NES evaluation? This section addresses this question.

Identify Content and Pedagogical Areas for NES

One of the challenges of evaluating a comprehensive STEM intervention program like NES is that it encompasses such a broad area and with a wide range of implementation strategies and resource components. The following suggestions would help NES narrow the focus of what it offers schools while also allowing NES to service grades K-16:

- Integrate standards of learning thematically for grades K-16 into the implementation plan.
- Integrate educational technology training as a critical component of curriculum training.
- Restructure family involvement to be more broadly focused on promoting and supporting science literacy and science career awareness for school families, caregivers, and community stakeholders to support NES individual school academic goals either directly or indirectly.

Increase the Rigor of How School-based Implementation Is Documented

Here are several suggestions to increase the rigor of the documentation of NES implementation while also providing useful data for ongoing improvements to NES:

- Restructure the e-Folio website. Give detailed instructions to teachers on what information they should report as the result of NES participation. Instead of random picture posting, the site should help teachers reflect on and document their implementation. Provide specific guidelines.
- Investigate in depth how teachers implement inquiry-based strategies and technology tools. While the case study and Teaching, Learning, and Computing data analyses showed that inquiry strategies were critical for a successful implementation, the Teacher Involvement pre-/posttest survey revealed that teachers did not incorporate inquiry at the level they had intended. This suggests the need for more school-based training, which might be manageable through the DLN or other online media.

Professional Development and Training Opportunities

We find several areas for improving the workshops and professional development offerings. The case study cross-case analysis found a strong correlation between student achievement gains and improvements in teaching strategies, increased content knowledge by teachers, and teachers' making systematic efforts to connect the NES intervention to specific standards for student performance. Here are some other recommendations:

- Design NES workshops, DLN training, and other professional development programs to address the factors above, and ensure the evaluation looks for indicators that these factors are being addressed. Evaluate the quality of workshops in each field center.
- As shown in the Teaching, Learning, and Computing regression analysis, technical skills and teaching strategies have the greatest impact on constructivist uses of

technology. To make NES professional development more effective, plan programs based on the needs of schools, teachers, and students rather than by organizing workshops according to NASA regional center resources. For example, focus workshops on increasing teachers' technical skills and knowledge about constructivist teaching strategies. Provide practice in and exercises for effective use of technology.

Research Designs for Future Evaluation

Ideally, we recommend that NES conduct a **randomized controlled trial** study for future evaluations. This research design could be done by accepting twice as many schools and using a stratified randomized process to assign schools to the NES intervention or to a control group for comparison. The outcomes of the two schools could then be compared on an annual basis.

On a more economical scale, we suggest that NES work with the Center for Educational Technologies evaluation team to **continue and expand the case study research** begun in the three-year period reported here. Using a cluster-based, randomized sampling strategy, additional case study research would further the evaluation process. If the recommendations provided above were implemented, the case study process would be the most effective way to collect evidence on how the NES intervention is being implemented by schools.

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	A	B	C	D	E	F
1		***Exceeds Expectations***	***Meets Expectations***	***Meets Minimum or Does Not Meet Expectations***	***Maximum Possible Points***	***Rating Scores***
2	**<u>Outcome 1:</u> Participation and professional growth of educators in science**	**6-8 points**	**3-5 points**	**0-2 points**	**48**	
3	*Guideline 1 - Instructional Strategies* *[data sources*: interview transcripts; surveys: TI, Adm, TLC; e-folio]*	Teachers <u>meet expectations</u> and: • Immerse students in scientific inquiry, questioning, and experimentation. • involve students in the process of generating and evaluating scientific evidence. • Model scientific reasoning.	In regard to their classroom teaching of STEM-G topics teachers apply what they've learned about inquiry methods to create learning environments that immerse students in: • Hands on investigations. • Cooperative learning activities.	In regard to their classroom teaching of STEM-G topics teachers describe: • Problems with not being able to implement inquiry methods in their classroom teaching. • Difficulties with or restrictions in implementing cooperative learning strategies.	8	
4	*Guideline 2 - Time Intensive* *[data sources: interview transcripts; surveys: TL, TI, FC; e-folio]*	Teachers <u>meet expectations</u> and: • Present information to other NES and non-NES schools. • View individual learning opportunities as part of an intensive and sustained professional development plan. • Express higher satisfaction with NES professional development (rating score mean is at least 4 out of 5).	Teachers: • Attend workshops and conferences. • Network with the learning community. • Share information with other NES and non-NES teachers. • Express satisfaction with NES professional development (rating score mean is at least 3 out of 5).	Teachers attend workshops and conferences, but: • Do not network with the learning community. • Do not share information with other NES and non-NES teachers. • Express dissatisfaction with NES professional development (rating score mean is less than 3 out of 5).	8	
5	*Guideline 3 - Classroom Practices* *[data sources: interview transcripts; surveys: SI, TL, TI, FC; e-folio]*	Teachers: • Integrate NASA resources and expertise (including AES) into their curriculum to increase student engagement and make learning relevant and meaningful. • Aim their teaching strategies and materials to improve student performance in STEM-G areas.	Teachers: • Integrate NASA resources and expertise (including AES) to encourage student engagement. • Aim teaching strategies and materials toward improving English, reading, language arts, and STEM-G instruction.	Teachers: • Do not use NASA resources or call upon NASA experts to encourage student engagement. • Do not attempt to adapt and implement NASA content materials into their curriculum. • Do not consider how they can aim their teaching to improve student performance.	8	

	A	B	C	D	E	F
1		***Exceeds Expectations***	***Meets Expectations***	***Meets Minimum or Does Not Meet Expectations***	***Maximum Possible Points***	***Rating Scores***
6	*Guideline 4 - Content Knowledge* *[data sources: interview transcripts; workshop reports; surveys: TL, TI, FC; Admin; e-folio]*	Teachers <u>meet expectations</u> and: • Recognize and know how to change common student misconceptions in STEM-G areas. • Improve pedagogical content knowledge–specific teaching practices for specific content, such as teaching forces and motion through dance moves (e.g., NASA FMA show).	Teachers: • Report or demonstrate increased knowledge of (and/or skills in) STEM-G content, careers, family involvement. • Describe or show use of (pedagogical content) inquiry, classroom management, lesson planning, or grouping methods gained by NES professional development.	Teachers: • Show no growth in their subject matter knowledge or skills. • Report no increased knowledge of STEM-G content, careers, or family involvement. • Describe or show no use of (pedagogical content) inquiry, classroom management, lesson planning, or grouping methods gained by NES professional development.	8	
7	*Guideline 5 - Active Learning* *[data sources: interview transcripts; workshop reports; surveys: TI, FC; Admin; e-folio]*	Teachers <u>meet expectations</u> and present, lead, or write about how to: • Become actively engaged in meaningful discussion, planning and practices to meet annual SOL and professional development goals. • Observe expert teachers and are observed teaching and receive feedback. • Plan how new curriculum materials and new teaching methods will be used in their classrooms. • Review student work in context to the topics being covered.	Teachers: • Demonstrate understanding of standards. • Show how to connect their work to specific standards for student performance. • Meet at least monthly to discuss STEM-G curriculum materials and teaching methods and to plan and reflect on NES implementation.	Teachers: • Demonstrate little to no understanding of standards. • Cannot show how to connect their work to specific standards for student performance. • Do not meet regularly to discuss STEM-G curriculum materials, teaching methods, or to plan/reflect on NES implementation.	8	
8	*Guideline 6 - Coherence* *[data sources: interview transcripts; workshop reports; surveys: TL, TI, FC; Admin; e-folio]*	NES reform strategies are connected to <u>three or more</u> aspects of school reform that promote: • Teacher professional growth. • Curriculum improvement (especially. in STEM-G areas). • Improving school climate. • Relationships with feeder schools and community. • Leveraging NES funding to pursue additional partnerships (i.e., with local colleges and universities) and funding.	NES reform strategies are connected to <u>at least two</u> aspects of school reform that promote: • Teacher professional growth in STEM-G areas is within the team and schoolwide. • Curriculum design (especially In STEM-G areas) strategies are consistent. • Improving school climate. • Relationship with feeder schools and community. • Leveraging NES funding to pursue additional partnerships (i.e., with local colleges and universities) and funding.	NES reform strategies are: • Not connected to other aspects of school reform. • Not consistent. • Not addressed as part of relationship with feeder schools. • No attempts are made to leverage NES funding or partnerships.	8	
9	*Comments on Outcome 1:*					

	A	B	C	D	E	F
1		***Exceeds Expectations***	***Meets Expectations***	***Meets Minimum or Does Not Meet Expectations***	***Maximum Possible Points***	***Rating Scores***
10	**Outcome 2: Assistance for and technology use by educators in schools with high populations of underserved students**	**3-4 points**	**1-2 points**	**0 points**	**16**	
11	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]	Meets expectations and: • Leverages NES funding for technology purchases with supplemental funding. • Technology purchased is integrated with school goals for STEM-G improvement.	Purchases software and hardware with NES funding that: • Supports school implementation of NES project. • Serves students with demographics that qualify for either (or both) Title 1 funding or assistance with English language learning.	Purchases NASA software and hardware with NES funding but: • technology purchased does not support school implementation of NES project because of technological, logistical, or training problems.	4	
12	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]	Meets expectations and: • Integrates DLN into school curriculum. • Participates in additional NASA technology-based opportunities such as the ISS downlink or web-based access to mission data	Teachers demonstrate at least one of the following: • Use of technology tools to support STEM-G, reading, language art curriculum. • Participation in DLN activities at the school.	Teachers show no evidence of: • Using technology tools to support STEM-G, reading, or language art curriculum. • Participating in DLN activities at the school.	4	
13	Guideline 3 - Teachers report frequency of using the technology in STEM-G context [data sources: interview transcripts; surveys: TLC; e-folio]	• Students use technology at least twice a week. • Link to STEM-G content is articulated in learning goals.	• Students use technology at least once a week. • Link to STEM-G content is clear.	• Students use technology only once or twice a month. • Link to STEM-G content is not clear.	4	
14	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]	Teachers meet expectations and: • Are comfortable with using technology tools for teacher preparation and other professional activities. • Use tools weekly.	Teachers: • Use technology tools for teaching preparation and other professional activities. • Use tools when required. • Demonstrate positive attitudes toward using technology as part of STEM-G instruction.	Teachers: • Show little to no evidence of using technology tools for teaching preparation or other professional activities.	4	
15	*Comments on Outcome 2:*					

	A	B	C	D	E	F
1		***Exceeds Expectations***	***Meets Expectations***	***Meets Minimum or Does Not Meet Expectations***	***Maximum Possible Points***	***Rating Scores***
16						
17		**7-10 points**	**3-6 points**	**0-2 points**		
18	**Outcome 3: Family involvement in children's learning** [data sources: interview transcripts; workshop reports; surveys: SI, TL, TI, FC; Admin; e-folio]	Teachers meet expectations and show evidence that parents: • Have opportunities to observe the changes in STEM-G curriculum and teaching strategies. • Have information to appraise teachers for the use of innovative teaching methods; and • Are encouraged to involve children in STEM-G activities outside of school.	Teachers provide evidence that parents: • Actively participate in the NASA-sponsored family events. • Are kept informed of NES project and STEM-G activities at the school. • Observe NES activities having a positive impact on overall school climate and community value of STEM-G content and careers.	Parents attend NES-sponsored family involvement activities at the school, but activities: • Are held infrequently. • Do not follow NES guidelines for family involvement activities.	**10**	
19	*Comments on Outcome 3:*					

	A	B	C	D	E	F
1		***Exceeds Expectations***	***Meets Expectations***	***Meets Minimum or Does Not Meet Expectations***	***Maximum Possible Points***	***Rating Scores***
20	**<u>Outcome 4:</u> Student interest and participation in science, technology, engineering, mathematics, and geography**	**2 points**	**1 points**	**0 points**	**8**	
21	*Guideline 1 - Participate productively in STEM-G practices and discourse* *[data sources: interview transcripts; e-folio]*	Teachers report that students participate in the science inquiry process using: • Real-time data. • Valid instruments for data collection. • Online scientific instruments (i.e., online telescopes).	Teachers report that students participate in the science inquiry process.	There is no evidence to show that students participate in STEM-G practices and discourse.	2	
22	*Guideline 2 -Show noticeable curiosity in STEM-G related topics and events* *[data sources: interview transcripts; surveys: TL, TI, FC; e-folio]*	Teachers report that students question and/or investigate STEM-G-related topics outside the classroom.	Teachers report that students relate STEM-G-related topics discussed in the classroom to current events or local phenomena.	There are no data indicators to show student interest or curiosity in STEM-G.	2	
23	*Guideline 3 -Change attitudes about learning* *[data sources: interview transcripts; surveys: SI; e-folio]*	Teachers report that: • Students are excited about learning and are asking more questions. • School scores on NES student interest test are above the mean in attitudes toward STEM-G topics and activities.	Teachers report that: • Students are excited about learning and are asking more questions. • School scores on NES student interest test are at or near the mean in attitudes toward STEM-G topics and activities.	Students show a neutral or negative attitude towards STEM-G-related activities.	2	
24	*Guideline 4 -Actively participates in hands-on and authentic scientific research* *[data sources: interview transcripts; surveys: SI; e-folio]*	Students: • Conduct hands-on activities in STEM-G areas • Use technology as part of STEM-G investigations.	Students participate in the hands-on activities or authentic scientific research.	There are no or few signs of student participation in hands-on activities or authentic scientific research.	2	
25	*Comments on Outcome 4:*					

	A	B	C	D	E	F
1		***Exceeds Expectations***	***Meets Expectations***	***Meets Minimum or Does Not Meet Expectations***	***Maximum Possible Points***	***Rating Scores***
26	**<u>Outcome 5:</u> Student knowledge about careers in science, technology, engineering, mathematics, and geography**	**3 points**	**2 points**	**0-1 points**	**9**	
27	*Guideline 1 - Change in self-identity* *[data sources: interview transcripts; surveys: SI; e-folio]*	• Teachers report that students see themselves as one of the NASA employees.	• Teachers report that students express interest in pursuing careers at NASA.	• Students did not express interest in pursuing careers at NASA.	3	
28	*Guideline 2 -Increased understanding of and enthusiasm about STEM-G careers* *[data sources: interview transcripts; surveys: SI, TI; e-folio]*	• Student interest survey scores show increased interest in STEM-G careers.	• Student Interest survey scores show average (between 2.25-2.75) interest in STEM-G careers.	• Student interest in NASA careers declines, or survey scores decline.	3	
29	*Guideline 3 -Share information with peers and parents* *[data sources: interview transcripts; surveys: SI; e-folio]*	• There is evidence of student engagement in peer sharing (or training) and sharing with parents. • Student presentations are featured at family or community outreach events that related to NES or other STEM-G learning.	• Opportunities for peer training or cross-school or community-based presentations by students are planned.	• There is no evidence of students being involved in peer sharing, training, or community presentations.	3	
30	*Comments on Outcome 5:*					

	A	B	C	D	E	F
1		***Exceeds Expectations***	***Meets Expectations***	***Meets Minimum or Does Not Meet Expectations***	***Maximum Possible Points***	***Rating Scores***
31	**Outcome 6: Student ability to apply science, technology, engineering, mathematics, and geography concepts and skills in meaningful ways**	**3 points**	**1-2 points**	**0 points**	**9**	
32	*Guideline 1 - Understand and use scientific explanations of the natural world* *[data sources: interview transcripts; surveys: SI, TI, FC; e-folio]*	There is evidence that students: • Understand and can use scientific explanations in STEM-G problem solving contexts.	There is evidence that students: • Understand and can use scientific explanations.	There is no evidence that students: • Understand or can use scientific explanations.	3	
33	*Guideline 2 - Understand, use, and interpret the nature and development of STEM-G topics* *[data sources: interview transcripts; surveys: SI, TI; e-folio]*	Students participate in research projects and/or science competitions such as GLOBE, NES student research conference, school science fairs and receive recognition for achievement through review process.	Students participate in science competitions or STEM-G related research projections.	Students did not participate in any science competitions or STEM-G research projects.	3	
34	*Guideline 3 - Increased achievement in math and language arts, reading, and science standardized tests* *[data sources: interview transcripts; State report card data]*	Student achievement scores: • Meet AYP in all areas; and • Exceed district (or state) achievement scores in all areas.	Student achievement scores: • Meet AYP in STEM-G; or • Exceed district (or state) achievement scores in science and/or math.	Student achievement scores: • Do not meet annual progress goals in science and math areas. • Students show no improvements in science and math. • Students do not meet annual progress goals in related subjects, such as language arts.	3	
35	*Comments on Outcome 6:*					

	A	B	C	D	E	F
1		***Exceeds Expectations***	***Meets Expectations***	***Meets Minimum or Does Not Meet Expectations***	***Maximum Possible Points***	***Rating Scores***
36						
37	**Bonus Points: *Great School Rating*** *www.greatschools.net/*	If school receives a Great School Rating between 8 and 10, ADD 2 points.	If school receives a Great School Rating between 6 and 7, ADD 1 point.	If school receives a Great School Rating less than 5, ADD 0 points.	2	
38	**TOTAL Points**				**102**	
39	*Definition of Data Sources					
40	Interview transcripts:					
41	2003 NES school teams were interviewed in the spring of 2005					
42	2003, 2004, and 2005 cohort case study school teams were interviewed in the spring of 2006					
43	Surveys:					
44	SI: Student Interest - taken by case study schools, spring 2006					
45	TL: Team Lead - taken by all NES team leaders, spring 2006					
46	TI: Teacher Involvement - taken schoolwide by NES and non-NES teachers at all NES schools, spring 2006					
47	FC: Field Center Staff - disseminated to field center education staff at all 10 NASA centers, spring 2006					
48	Admin: Administrator - completed by NES team administrators, spring 2006					
49	e-folio: An electronic portfolio for the NASA Explorer Schools project <http://aesp.nasa.okstate.edu/efolio/>					