THEMIS 2003-2009—TIME HISTORY of EVENTS and MACROSCALE INTERACTIONS during SUBSTORMS

FINAL EVALUATION REPORT

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CORNERSTONE EVALUATION ASSOCIATES LLC
205 Peddler Place • Pittsburgh, PA 15212-1975 • T:412.734.5220 • F:412.734.5221 • www.cornereval.com

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EXECUTIVE SUMMARY

The NASA-funded THEMIS mission was designed to determine the onset time and location of magnetic substorms of Earth's space environment, a prerequisite to understanding space weather. THEMIS is an acronym for Time History of Events and Macroscale Interactions during Substorms. As the THEMIS' spacecraft were being built and tested for a 2007 launch, a team of space scientists and astronomers at the Space Sciences Laboratory (SSL) at the University of California, Berkeley had already begun its mission-related education and public outreach (E/PO) work.

Starting in 2003, the team embarked on a journey to develop a multi-year, multi-faceted E/PO program geared to underserved, underrepresented populations across the nation. Bringing the excitement of THEMIS-related science to the public, students and teachers has been at the heart of all aspects of this effort. Recognizing a need to improve education in mathematics, science and technology (STEM), the THEMIS team entered into partnerships with science centers, K-14 educators, professional science organizations and mission scientists to implement a comprehensive program of formal and informal education. The E/PO effort consists of three components that address the professional development needs of science educators—the GEONS project, a GEMS site launch and short-term workshops. An additional two components are geared to the general public—the E/PO Web site and the ViewSpace show.

The THEMIS E/PO team engaged Cornerstone Evaluation Associates LLC, a Pittsburgh-based, client-centered research firm specializing in program evaluation, to conduct a comprehensive, multi-year evaluation of each of these components. The purpose of this evaluation was to ensure that the team had sufficient and appropriate evaluative data for making program improvements where warranted (formative) and for determining program effectiveness (summative). The evaluation approach called for multi-methods to collect both quantitative and qualitative data from program participants.

Moreover, when measuring the impact of each THEMIS component, the evaluation plan considered the extent to which program outcomes met not only THEMIS E/PO goals/objectives, but also NASA's key factors of success. The specific goals of the THEMIS program were derived from critical factors that the NASA Science Mission Directorate (SMD) considers when evaluating proposals—intrinsic merit, relevance to NASA objectives, cost and program balance factors. Therefore, in the final evaluation of the THEMIS E/PO program, these factors are revisited and used as an additional benchmark for program effectiveness.

This report documents the THEMIS program's evaluation results and is organized into four chapters reflecting each of the program's components as well as a final chapter discussing THEMIS' future. What follows in this executive summary are highlights from each of these chapters.

PART 1: Formal Education—GEONS Project—The Geomagnetic Event Observation Network by Students (GEONS) project was the flagship, formal education component of the E/PO program. With the placement of magnetometers in the proximity of rural schools throughout the country, middle and high school teachers along with their students benefited from the opportunity to work with 'real-time' data and participated in hands-on space science activities. Particular attention was paid to placing the magnetometer stations at schools in rural communities whose students were traditionally underserved and underrepresented in the sciences. The project offered to the teachers of these students long-term professional development opportunities that centered around THEMIS-related space science and the magnetometer data. Highlights of this component are...

- Placed magnetometers sites at 13 rural, underserved schools/communities, two-fifths of which are on tribal lands
- Provided intensive professional development for 20 teachers from 2004 through 2009
- A core group of eight teachers estimated reaching more than 2,720 students with THEMIS-related materials/ideas

- 75% of these students are minorities in science—either girls or non-Asian, non-White boys
- Core teachers provided evidence of the project's positive impact on students' attitudes toward science and their choices for courses that position them for STEM-related careers
- Core teachers reported sharing THEMIS-related materials/ideas with 275 colleagues
- Assisted by select teachers piloting activities and offering feedback, the THEMIS team developed four teacher guides containing 17 THEMIS-related classroom activities
- *The NewsHour with Jim Lehrer* featured the Petersburg, Alaska site potentially reaching more than 5 million viewers in two airings, according to Nielsen ratings
- *The PBS NewsHour* piece was picked up by National Public Radio and made available on the Online *NewsHour* Web site where it was linked to *NOVA Science NOW*'s Web site
- Nearly all core teachers have become involved in other NASA-related programs—Heliophysics Educator Ambassadors, GSFC's Cosmic Times, SOPHIA, RBSE, etc.

PART 2: Formal Education—GEMS Site Launch—A second formal education component involved the THEMIS team partnering with the Berkeley-based Lawrence Hall of Science (LHS) in 2005 to create a GEMS Network site at the Carson City School District in Carson City, Nevada. The highlight of this launch was a two-day teacher professional development workshop. GEMS (Great Explorations in Math and Science) is a proven resource for excellence in inquiry-based mathematics and science with guides used nationwide from preschool through eighth grade. To support the growing number of teachers using GEMS materials, LHS maintains an international network of over 65 sites and centers offering professional development and a variety of other teacher services. Launching a center in Carson City met the needs of the THEMIS program by offering an abundance of underserved school districts including those on tribal lands. Moreover, the site launch provided myriad opportunities for partnering from which grew the supportive relationships necessary to ensure the site's sustainability. Finally, Carson City was an excellent prospect for magnetometer installation due to its remote location. Highlights of this component include…

- 2005 GEMS site launch in Carson City, NV marked the beginning of what continues today as an independently operating site that uses district funds, fees and grants to support its work, while at the same time maintains contact with LHS
- The site launch provided a two-day, extensive workshop experience to 42 elementary and middle school teachers, primarily from Nevada
- Participating teachers were predominantly from underserved, underrepresented districts with almost half being rural locales
- Workshop participants reported having the potential to expose 3,500 preK-8 students to GEMS materials/ideas
- One-third of these students represent minorities
- Workshop participants reported having the potential to share GEMS materials/ideas with 1,500 colleagues; our three case study teachers alone shared GEMS with 150 colleagues
- Some 180 teachers have participated in site workshops in the first three years after the launch
- 150 teachers are on a LISTSERV and a Google group associated with the GEMS site

PART 3: Formal Education—Short-term Workshops—The third and final formal education component of the THEMIS program consisted of short-term professional development workshops presented to K-12 teachers nationwide. They offered some of the same THEMIS-related content that was presented to the GEONS teachers, except that these workshops were one-time events having durations of only one-hour to two days; not ongoing professional development projects like GEONS. Primarily, the workshops were conducted at state and national conferences. Special effort was made to reach teachers with Native American and Latino students by presenting workshops at such venues as AISES and SACNAS. In most cases, presentations of THEMIS-related materials/ideas were made in partnership with other NASA-sponsored missions and programs. Partnering with the ELISA project provided unique opportunities to further extend the reach of the program by targeting teachers of students in Latino/Hispanic populations. Highlights for short-term workshops include…

- Throughout the grant period, the E/PO team conducted some 30 short-term workshops for 550 K-12 educators nationwide
- The vast majority of these workshops were done in partnership with other NASA missions and programs—ELISA, FAST, RHESSI, STEREO and SECEF
- The E/PO team estimates that within a year of the workshops' participating teachers will reach upwards of 48,400 students and share THEMIS-related materials/ideas with around 2,200 colleagues
- A core group of these teachers reported that 68% of their students were underserved minorities in science education

PART 4: Public Outreach—Beyond the Classroom—'Spreading the word' about THEMIS-related science to venues beyond the classroom entailed two informal, public outreach components—the Web site and the ViewSpace museum show. The Web site opens the 'window on the soul' of the mission's discoveries in a language accessible to a general audience as well as serving as a valuable resource/reference for teachers and students alike. The ViewSpace presentation—'Probing the Mysterious Aurora'—has captured the attention of planetarium and science center visitors around the world by drawing them into the story of THEMIS.

- The THEMIS E/PO Web site has had close to 900,000 successful requests for pages since its launch in 2003
- Visitors from 118 countries, including the USA, have viewed the Web site since it was started in 2003
- The ViewSpace museum show is currently in 200 museums and science centers around the world and is estimated to have been shown 5,500 times per month
- The network of museums in which ViewSpace is exhibited grows at a rate of 3 to 4 per month

PART 5: Infinity and Beyond—The Future of THEMIS—This concluding chapter establishes that the THEMIS E/PO program has built a firm foundation for sustaining its efforts to disseminate THEMIS-related science. This rock-solid base was formed during NASA's 2004 White Paper Review as well as through 'lessons learned' during periodic evaluative feedback and by observation and self-reflection. This final section also reveals new initiatives that ensure the THEMIS E/PO program's continuation far into the future. Paramount among these is the Heliophysics Educator Ambassador program—a new E/PO program involving THEMIS and six other heliophysics-focused partners. Its goal is to develop the capacity of over 70 educators to train other teachers on NASA heliophysics science and educational resources. Moreover, coordination with a variety of partners affords THEMIS E/PO many opportunities to disseminate resources nationally without duplication of effort.

PREFACE

The NASA-funded THEMIS mission was designed to determine the onset time and location of magnetic substorms of Earth's space environment, a prerequisite to understanding space weather. THEMIS is an acronym for **T**ime **H**istory of **E**vents and **M**acroscale **I**nteractions during **S**ubstorms.

The launch of the five THEMIS satellites on February 17, 2007 marked a significant milestone for the mission. As the spacecraft were being built and tested, a team of space scientists and astronomers at the Space Sciences Laboratory (SSL) at the University of California, Berkeley had already begun its mission-related education and public outreach (E/PO) work. Starting in 2003, the team had embarked on a journey to develop a multi-year, multi-faceted E/PO program geared to underserved, underrepresented populations across the nation. Bringing the excitement of THEMIS-related science to the public, students and teachers has been at the heart of all aspects of this effort.

The nature of THEMIS science holds the potential for inquiry-based instruction at all grade levels—with most direct application for high school students. Recognizing a need to improve education in mathematics, science and technology (STEM), the THEMIS team entered into partnerships with science centers, K-14 educators, professional science organizations and mission scientists to implement a comprehensive program of formal and informal education. The E/PO effort consisted of three components that addressed the professional development needs of science educators and two components geared to the general public…

Formal Education	• The GEONS Project—Geomagnetic Event Observation Network by Students • GEMS Site Launch in Nevada • Short-term workshops for teacher professional development
Informal Education & Public Outreach	• THEMIS Web Site • ViewSpace for museums and science centers

To complement professional development workshops, the E/PO team supported classroom visits by mission scientists and engineers. Additionally, the E/PO team partnered with a Public Relations group at NASA'S Goddard Space Flight Center to augment their efforts in attracting visitors to the Web site.

The THEMIS program's goals/objectives for formal education were to…

- Share the excitement of real-time measurements [magnetometer] with science teachers and their students
- Develop physical science and Earth and space science lesson plans for nationwide classroom use—adhering to National Science Education Standards (NSES) at appropriate grade levels, incorporating THEMIS data and providing background content for THEMIS teachers on the mission and magnetometers
- Share THEMIS science in the context of other NASA missions such as FAST, STEREO and RHESSI
- Provide teachers nationwide with professional development opportunities to learn more about auroras and solar storms and to take appropriate lessons back to their classrooms

- Use existing infrastructure in order to avoid duplication of effort
- Partner with Tribal Colleges, schools on tribal lands and the Society for Advancement of Chicanos and Native Americans in Science (SACNAS) to reach minority and underserved groups
- Motivate scientists' involvement in E/PO

And, the THEMIS program's goals/objectives for public outreach were to…

- Share THEMIS discoveries with teachers, students and the general public through well-developed E/PO Web pages
- Share with the museum-going public nationwide the awe of auroral substorms and the mystery of the trigger of these substorms' dynamic displays

These THEMIS program goals find their origin in the critical elements that the NASA Science Mission Directorate (SMD) considers when evaluating proposals. In crafting the objectives that guided the design of THEMIS program components, the E/PO team turned to NASA's elements/factors—intrinsic merit, relevance to NASA objectives, cost and program balance factors. These factors and their sub-factors are discussed in greater detail at the conclusion of 'Part 1: Formal Education—GEONS Project'.

The THEMIS E/PO team engaged Cornerstone Evaluation Associates LLC, a Pittsburgh-based, client-centered research firm specializing in program evaluation, to conduct a comprehensive, multi-year evaluation of the THEMIS program. The purpose of this evaluation was to ensure that the team had sufficient and appropriate evaluative data for making program improvements where warranted (formative) and for determining program effectiveness (summative). The evaluation approach called for multi-methods to collect both quantitative and qualitative data from program participants. Quantitative data were summarized predominantly as descriptive statistics using the Statistical Package for the Social Sciences (SPSS), while qualitative information was content analyzed to reveal emerging themes.

The main purpose of this report is to present the broad-ranging outcomes of the THEMIS E/PO effort—outcomes that reveal the program's effectiveness. Throughout this document, these outcomes are summarized in two ways—1) they are discussed in light of the overarching NASA goals and 2) they are mapped into the nine specific goals/objectives of the THEMIS E/PO program itself. At the conclusion of each of the first four chapters, chronicling the outcomes of THEMIS program components, a discussion is set forth of how the featured component addresses NASA's goals. In the fifth and concluding chapter, these outcomes are mapped to the specific program goals delineated above. This final chapter also provides a glimpse into future projects that are spinning off from THEMIS and thus ensuring the sustainability of THEMIS programming.

While this report represents the culminating, comprehensive summary of THEMIS evaluation results, companion documents provide critical descriptive narratives and data from the development of the multi-component E/PO program itself. Evaluation reports from throughout the program are available on the THEMIS E/PO Web site at http://ds9.ssl.berkeley.edu/themis/aboutus_evaluations.html (under E/PO Evaluation).

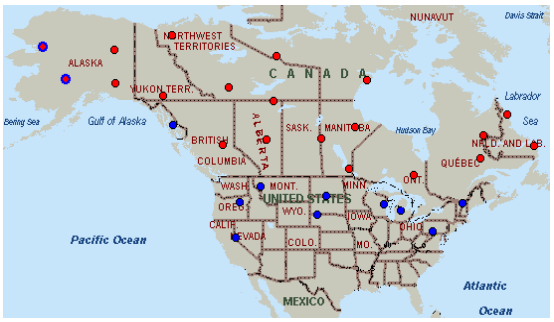
Also, for the benefit of fellow education outreach professionals, the E/PO team has authored a journal article offering interim findings and 'lessons learned' from their THEMIS experience.[L.M. Peticolas et.al., The Time History of Events and Macroscale Interactions during Substorms (THEMIS) Education and Outreach Program, Space Sci. Rev. (2008), 141:557-583, doi:10.1007/s11214-008-3458-5]. The reprint of this article is available from the THEMIS E/PO team at the Space Science Lab, University of California at Berkeley.

This report is organized into five chapters as follows…

- Part 1: Formal Education—GEONS Project
- Part 2: Formal Education—Gems Site Launch
- Part 3: Formal Education—Short-Term Workshops
- Part 4: Public Outreach—Beyond the Classroom
- Part 5: Infinity and Beyond—The Future of THEMIS

PART 1: FORMAL EDUCATION—GEONS PROJECT

"[The GEONS project] made me a better scientist…It gives me access to data, real data that I then can turn over to students. So as an educator I become more of a facilitator. When I can get my hands on good 'real-time' data that the students can then utilize, it makes me a better educator rather than just a teacher."*—GEONS Teacher*



The Geomagnetic Event Observation Network by Students (GEONS) project was the flagship, formal education component of the THEMIS Education and Public Outreach program. With the placement of magnetometers in the proximity of 13 rural schools throughout the country, high school teachers and some middle school teachers along with their students benefited from the opportunity to work with 'real-time' data and participated in hands-on space science activities. (These school sites are denoted in the figure by blue and blue-circled red dots; the solid red dots are ground-based observatories that are part of the THEMIS science mission.) Particular attention was paid to placing the magnetometer stations at schools in rural communities whose students were traditionally underserved and underrepresented in the sciences. The project offered long-term professional development opportunities for the teachers of these students that centered around space science and the magnetometer data.

GEONS teachers selected for the project enjoyed access to NASA's magnetometer equipment, receiving 'real-time' data from the five THEMIS satellites. They also had access to the expertise of space scientists who provided training in its use and offered ideas for incorporating the mission's science into classroom lessons. Teachers received and were guided in the use of THEMIS-themed materials including a users guide and a teacher guide to classroom activities. Consequently, these GEONS teachers became well-positioned to inspire their students to learn about Earth's magnetic field and its changes.

Over the course of five years, from the first summer meeting in 2004 through May 2009, a total of 20 teachers participated in the GEONS project. During this period, four professional development workshops were offered. The workshops afforded an opportunity for the E/PO team not only to present THEMIS-themed materials to the teachers, but also to interact with them as they were implementing the activities. In-depth feedback from the teachers was obtained from evaluative telephone interviews that guided revisions to the activity guides.

GEONS FAST FACTS

- ☼ *Placed magnetometers sites at 13 rural, underserved schools/communities, two-fifths of which are on tribal lands*
- ☼ *Provided intensive professional development for 20 teachers from 2004 through 2009*
- ☼ *A core group of eight teachers estimated reaching more than 2,720 students with THEMIS-related materials/ideas*
- ☼ *75% of these students are minorities in science—either girls or non-Asian, non-White boys*
- ☼ *Core teachers provided evidence of the project's positive impact on students' attitudes toward science and their choices for courses that position them for STEM-related careers*
- ☼ *Core teachers reported sharing THEMIS-related materials/ideas with 275 colleagues*
- ☼ *Assisted by select teachers piloting activities and offering feedback, the THEMIS team developed four teacher guides containing 17 THEMIS-related classroom activities*
- ☼ *The NewsHour with Jim Lehrer featured the Petersburg, Alaska site potentially reaching more than 5 million viewers in two airings, according to Nielsen ratings*
- ☼ *The PBS NewsHour piece was picked up by National Public Radio and made available on the Online NewsHour Web site where it was linked to NOVA Science NOW's Web site*
- ☼ *Nearly all core teachers have become involved in other NASA-related programs—Heliophysics Educator Ambassadors, GSFC's Cosmic Times, SOPHIA, RBSE, etc.*

The *THEMIS-GEONS Users Guide* served as an invaluable resource manual for teachers as they embarked on their journey within the magnetometer network. Additionally, the E/PO team prepared a teacher guide that included nationally-tested, inquiry-based activities designed for classroom use. The original teacher guide was subsequently divided into four distinct guides—with critical revisions stemming from teachers' evaluative feedback about their experiences in working with the activities in their classrooms. The revised activities guides are now available on the THEMIS Web site http://ds9.ssl.berkeley.edu/themis/classroom.html and are titled as follows…

- *Magnetism and Electromagnetism*
- *Exploring Magnetism on Earth*
- *Space Weather*
- *Earth's Magnetic Personality*

GEONS teachers were also given access to learning materials such as the Problem of the Week (math problems e-mailed weekly to teachers from the E/PO team) and PowerPoint presentations for enhancement of classroom instruction in space science concepts.

During the project's five years, evaluators gathered both formative and summative data from the GEONS teachers on seven occasions. Two methods were used—self-report questionnaires administered at the end of each workshop (tan in Table 1) and in-depth telephone interviews (blue) conducted over the project's course. Nineteen of the 20 teachers participated at least once in these data collection opportunities, with most doing so multiple times. Four of the teachers completed all seven questionnaires and interviews. Table 1 displays a summary of points at which GEONS teacher data were collected.

THEMIS—GEONS PROJECT
Data Collection Points

Date	Data Points	Workshop Location	# Teachers	Focus
July 2004	2-day GEONS Teachers Workshop	Berkeley, CA	N=9	Feedback about workshop
January 2005	GEONS Teachers Interview	—	N=7	Reactions to project 6-months out from initial workshop
June 2005	2-day GEONS Teachers Workshop	Carson City, NV	N=9	Feedback about workshop and overall project
March 2006	GEONS Teachers Interview	—	N=8	Support materials—guides and lessons
March 2007	2-day GEONS Teachers Workshop at NSTA	St. Louis, MO	N=8	Feedback about workshop as well as implementation, dissemination, student impact, professional development
July 2008	2-day GEONS Teachers Workshop	Boulder, CO	N=12	Feedback about workshop
March/May 2009	GEONS Teachers Interview	—	N=9	Summary of all teacher efforts in implementation, dissemination as well as teacher perceptions of student impact

TABLE 1. GEONS PROJECT—Data Collection Points. Points of data collection during five-year GEONS project.

In this chapter, findings from this extensive data collection effort are organized under the following topics…

- GEONS workshops
- THEMIS-themed curricular materials
- Implementation and dissemination
- Key factors for success

Findings from the end-of-workshop questionnaires are featured in 'GEONS workshops'. The results of the first two telephone interviews are summarized in 'THEMIS-themed curricular materials' with the findings from the final, exit interview highlighted in 'Implementation and dissemination'. 'Key factors for success' discusses the GEONS project vis-à-vis NASA's goals and objectives.

GEONS Workshops—Teachers Delve into THEMIS

The summer 2004 workshop marked the introduction of the THEMIS program to GEONS teachers and the beginning of their formal education in the science it would bring to their classrooms. With the 2005 completion of magnetometer installation at the original ten sites, GEONS teachers working at these sites were in a position to begin sharing 'real-time' data with their students. Subsequently, three more sites were added. Currently, the data from each site continue to be available on the THEMIS Web site and can be used by teachers and students across the country, including those at other magnetometer sites.

To reinforce and strengthen GEONS teachers' initial introduction in 2004 into THEMIS-related science, three additional opportunities for formal education were offered at two-day workshops conducted in 2005, 2007 and 2008. These workshops served the needs of the pioneering GEONS teachers as well as those who joined the project as the number of magnetometer sites increased to 13. Additionally, the workshops were valuable for the new teachers who replaced the few who had to leave the project. Through the strength of partnerships that the E/PO team built with superintendents and principals, 'vacancies' were quickly filled.

Workshop attendees and THEMIS instructional/evaluation team pose for final 'class picture'.

Not all support for GEONS teachers came from formal professional development workshops and teacher guides. The E/PO team communicated with and continued to support GEONS teachers via e-mails, teleconferences and the THEMIS Web site. A Yahoo! Group set up for GEONS teachers along with telephone contact also served as communication strategies to keep the E/PO team connected to GEONS teachers and to support collaboration among the teachers themselves. In short, teachers were not left to 'go it alone' in their quest to bring THEMIS-related science into their classrooms.

Demographic information for all GEONS teachers touched by the project is summarized in this section. An overview of the findings from the four professional development workshops they attended is presented next. GEONS teachers' reflections on their training experience round out the tale of professional development. This information is discussed in the following sections…

- GEONS teacher demographics
- A chronology of workshop findings
- Reflections on training—The 'big picture'

GEONS Teacher Demographics

Over the course of the workshops, GEONS teachers revealed information about themselves and the environments in which they teach. These data are bulleted below providing a picture of underserved communities with students underrepresented in the sciences...

- Of the 13 magnetometer sites, about two-fifths are on tribal lands
- Most GEONS teachers work in rural schools
- The average number of students in these schools is slightly over 600
- The average number of faculty in these schools is slightly over 40
- On average, half of the GEONS teachers' students are female, with class composition ranging from 30% to 65% females. Females are traditionally underrepresented in the sciences.
- On average, more than three-fifths (61%) of the GEONS teachers' students are minorities—ranging from 2% to 100% minorities with Native American and Native Alaskan students predominating. Minority students are typically underrepresented and underserved in the sciences.

GEONS teachers' educational backgrounds, teaching experience and circumstances are, in summary…

- Nearly all GEONS teachers have undergraduate degrees in the sciences, but only a few have degrees with a major in physics
- The majority of GEONS teachers have science degrees beyond their bachelor's degrees
- The average GEONS teacher has almost 17 years of teaching experience
- All GEONS teachers are teaching at the middle or high school level

A Chronology of Workshop Findings

GEONS teachers participating in each workshop completed end-of-workshop questionnaires. These questionnaires captured mostly summative data focusing on teachers' experiences in implementing and disseminating the THEMIS-based materials as well as their reactions to the training they were receiving. In this section we present snapshots of workshop findings that reveal the evolution of GEONS teachers' implementation and dissemination efforts. A synthesis of these efforts across all five years of the GEONS project is presented later in this chapter.

In addition to these summative data, formative data were gathered in the 2004 and 2007 workshops. At the end of each day, GEONS teachers filled out short forms requesting narrative information about the day's presentations. This daily feedback provided critical information for improving presentations and keeping the sessions 'on track'.

July 2004—Berkeley, CA—GEONS teachers representing nine of the ten original magnetometer sites in AK, MI, MT, ND, NV, OR, PA, SD and WI attended the first workshop. The teacher from the VT site was unable to participate. The two-day workshop introduced teachers to the project and its THEMIS-related science in anticipation of the upcoming magnetometer installations. After the workshop, teachers were given the opportunity to participate in an additional half-day activity at the Chabot Space and Science Center in Oakland, CA. Feedback gathered from teachers concentrated on their perceptions of the workshop itself.

The primary goal of the first workshop was to introduce the project and mission science to GEONS teachers. It was gratifying to find that teachers rated their understanding of the mission, their role in it and the upcoming installation of the magnetometer very high. Mean ratings of understanding for these three topics ranged between 5.8 and 6.1 on a 7-point continuum with assigned values at '1=none', '3=novice' and '7=expert'.

"I feel more like I understand what will be happening and expected from me and my site and from the magnetometer itself."—*GEONS Teacher*

Teachers let it be known that they liked THEMIS-related, hands-on activities and appreciated learning ways in which they could bring mission science into their classrooms. They also expressed their appreciation for the opportunity to interact with colleagues and THEMIS experts. With high praise for the workshop, there was little about it they would have changed. Teachers offered suggestions that eventually led to workshop and project improvements…

- Make the workshop one day longer
- Make each day shorter
- Increase opportunities to share and collaborate with other teachers
- Provide updates on the progress of the mission
- Create an e-mail support network for teachers

June 2005—Carson City, NV—Nine GEONS teachers representing the magnetometer sites of AK, MI, MT, NV, OR, PA, SD. VT and WI attended the second professional development workshop. The ND site was not represented inasmuch as the GEONS teaching position was in transition. Two of the teachers, in attendance, reported that installation of the magnetometers had not yet been completed. This work was carried out during the summer, so that the magnetometers were up and ready for the 2005-06 school year. Feedback from the end-of-workshop questionnaire concentrated on teachers' perceptions of the workshop and the overall project. They were also asked about any steps they had taken toward implementing and disseminating THEMIS-related ideas/materials.

Workshop presentations included not only 'how-to' sessions for using THEMIS lessons and mission science, but also a tutorial for joining the Yahoo! Group. Again, teachers said they found the presentations to be very clear—mean ratings for understanding ranged from 3.6 to 3.8 on a 4-point scale with '1-not clear at all' to '4-very clear'. Teachers indicated they would be 'very likely' to present this material, could foresee no barriers to implementing what they had learned and would be comfortable sharing ideas/materials with students and colleagues in both formal and informal settings. Some of the teachers suggested that the workshop format could be improved by either streamlining what is covered or increasing presentation time. Teachers continued to indicate that they appreciate opportunities to interact/collaborate with their colleagues.

GEONS teachers gain 'hands-on' experience.

Teachers were asked to reflect on the overall GEONS experience as they marked one year since their formal introduction to the THEMIS program. They revealed that their primary **motivation for participating** in the program was the desire to inspire their students and involve them in 'real science'. They also cited their interest in astronomy, space science and the THEMIS program among the personal reasons compelling them to seek out the experience. As they embarked on **implementing THEMIS lessons** in the physical sciences, physics, general science and astronomy, more than half the teachers indicated that they were still trying to get comfortable with the materials. Toward that effort, more than two-thirds of the teachers said that the THEMIS team did not need to provide additional support. Many said they just needed more of the support they were already receiving—workshops, news updates and prepared lessons/activities.

"The opportunity to present 'real-life' technology to students and involve them in actual scientific research…that has global implications that were too awesome to pass up."—*GEONS Teacher*

As the program began to get rolling, GEONS teachers stated that their **dissemination efforts** were most often taking the form of informal sharing with their colleagues. Almost one-third (29%) was beginning to make formal presentations at state science teacher conventions and the same percentage was using mass media and the Internet in their efforts. Two-thirds of the teachers noted that they had future plans for making more formal presentations at district, state and national educational conferences and other venues.

March 2007—NSTA at St. Louis, MO—Eight GEONS teachers representing the magnetometer sites of AK (2), MI, ND (2), NV, OR and SD attended a workshop designed specifically for them as they gathered for the national meeting of science teachers. The GEONS teachers, at this point, had as much as three years of project experience. Five of the teachers had been participants since the 2004 inception of the project, two since 2005 and one joined the project in 2006. Feedback was concentrated on the workshop as well as implementation, dissemination and student impact.

The focus of this workshop was to present activities included in a newly-developed, fourth teacher's guide—*Earth's Magnetic Personality*—that was being rolled out for classroom use. GEONS teachers had already been using the first three guides in the series that were at this point available on the THEMIS Web site. Activities from the new guide were developed by the THEMIS leadership team and revised based on evaluative feedback from select GEONS teachers as well as from teacher research done during Summer 2006.

GEONS teachers indicated that presentations of the six activities from *Earth's Magnetic Personality* were 'clear', offering a mean rating of 3.5 on a 4-point scale. Seven of the eight teachers said that they had tried at least one of the activities prior to the workshop. Teachers signaled that they were 'very likely' to use the activities that they had not yet tried as indicated by a 4.4 mean rating on a 5-point scale, ranging from '1-will not use' to '5-certain to use'. When asked if they could foresee any barriers to implementation, most (63%) of the GEONS teachers cited their concerns about fitting the activities into the basic curriculum as well as time constraints.

As GEONS teachers **implemented mission science**, they all said they were using THEMIS materials, including guides and the Web site. They reported that they were using THEMIS primarily in Earth science/geology, astronomy and physics/physical science classes. Once the THEMIS program ends, all eight teachers said that they plan to continue using THEMIS-related materials and data from the magnetometers. Many (57%) teachers feel they will not need additional help to do so, but would like to see teleconferences, updating/revision of activity guides and networking continue.

"All of the material sustains itself by the very nature of the subject matter."—*GEONS Teacher*

Nearly three-fifths (57%) of the GEONS teachers reported seeing increased general interest in science among the elementary, middle and high school populations in their schools and school districts. Nearly three-fifths (57%) also said that active participation in the project, 'real-time science', has sparked interest as students feel a vital connection to the mission. Students are inspired by the materials and instructor enthusiasm. Teachers have also reported increases in science course enrollment.

"We will be adding THEMIS-themed materials to a nature-walk sign station on a walking trail that is currently being developed by the local community."—*GEONS Teacher*

GEONS teachers engaged in multiple means of **disseminating THEMIS materials**, both informally and formally. Most (86%) of the GEONS teachers said that they share THEMIS ideas/materials on an informal basis with their colleagues in department meetings, at lunch, in teachers' rooms, etc. More than two-fifths (43%) shared THEMIS ideas/materials by making presentations at state teachers' conferences and within the community. Nearly three-fifths (57%) of the teachers have gained local or national media exposure. GEONS teachers also reported that they update the school's Web site with THEMIS news, make presentations at local community groups and are planning activities for future dissemination.

Inspired by their involvement in THEMIS, the GEONS teachers have signed up for other NASA-related projects such as Cosmic Times, have attended NSTA conferences, and have participated in research/student activity projects such as RBSE (Research Based Science Education program sponsored by NOAO—National Optical Astronomy Observatory).

July 2008—Boulder, CO—Twelve GEONS teachers representing the magnetometer sites of AK (2), MI, MT, ND, NV (3), OR, PA, VT and WI attended the final professional development workshop. Four of those attending were newcomers to the project, having joined within the previous twelve months. This workshop included presentations of revised activities from one of the teacher guides. Additionally, four GEONS teachers shared their work. These select teachers had been recruited to complete research with the magnetometer data and produce lessons involving students. The workshop also featured a tour of NCAR (National Center for Atmospheric Research). With an awareness that an in-depth exit interview focusing on implementation, dissemination and student impact would be conducted shortly, feedback from this workshop concentrated on the workshop itself.

Mean ratings of understanding for the topics presented over the two-day workshop ranged from 3.2 to 3.9 on a 4-point with '1-not clear at all' to '4-very clear'. Teachers indicated they were very likely to use all of the topics and materials in their classrooms. Of particular note was the inclusion of a tour of NCAR—teachers were quick to see the potential for the tie-in of its science to their classrooms. All twelve teachers praised the tour, touting its value and finding it 'awe-inspiring.' Additionally, one teacher noted that "the idea of having the on-site dinner and networking with others was superb."

"The NCAR tour introduced us to tools such as supercomputers to solve large-scale scientific problems (climatology) relevant to the community-at-large. It also created a lot of enthusiasm on the Sun and how to introduce these activities in the classroom."—*GEONS Teacher*

All twelve teachers said they planned to implement all or some of the topics presented by their fellow GEONS teachers. These presentations included lessons designed to use magnetometer data for student research. Additionally, the four teachers who were new to the project were asked how they were currently implementing or planning to integrate THEMIS science into their classrooms. Two reported already having students engaged in gathering data and incorporating these data into lessons, while two were still in the planning stages of implementation.

Half of the teachers said they needed no additional help in implementing or disseminating the THEMIS ideas/materials. From among the remaining six teachers, four suggestions emerged. They were…

- Provide teachers with methods to better teach other teachers about the science
- Provide even more information about the satellite data and how to use it
- Create more activities using Kepler's laws, climate and space weather
- Allow more time for teachers to collaborate, brainstorm and develop activities for classroom use during the workshop

Reflections On Training—The 'Big Picture'

In the Spring 2009, some nine months after the last GEONS workshop, a 'core' group of the most involved GEONS teachers participated in an 'exit' interview. Among other things, they were asked to reflect on THEMIS-based professional development and consider how their experiences positioned them to implement THEMIS-related ideas/materials—see this chapter's 'Implementation and Dissemination' section for a comprehensive account of the findings from this interview.

Here we present three of the most important findings about training that emerged from these final conversations with veteran GEONS teachers. First, there was consensus among the teachers that the THEMIS program should be embraced by NASA E/PO as a model for providing teachers with formal, professional development. We paraphrase below one teacher's comments about the **extraordinary training experience provided by THEMIS leaders…**

> One GEONS teacher believed that the summer workshops were the strongest piece of the GEONS experience, because during these times teachers were trained extensively. According to this teacher, GEONS teachers were not just given equipment and guides and left "to hang." In fact, this teacher believes that the GEONS experience should be a model for NASA E/PO efforts in training teachers to be involved in and use 'real-time' data. This teacher said, "If you want to improve education, you must take programs like the THEMIS program, get a core group of teachers and say ok, let's explain it, now go back and teach your students….and the THEMIS leaders will be involved with you all the way".

Two critically important recommendations arose from this final interview. Some teachers **encouraged more repetition of mission science…**

> The overall scope of the THEMIS mission and its science were presented in the beginning of the project when the GEONS teachers were still quite naïve about what was going on. According to this teacher—as GEONS teachers worked toward their own understanding of the magnetometer, how it worked and how to use its data in the classroom, they became less 'in touch' with the big picture of the mission science. This teacher believes it is difficult for teachers of varied science backgrounds, even within physics, to understand areas outside their direct interest. This teacher felt that it may be beneficial to repeat the mission's overview at each meeting to remind teachers of the 'big picture'. This would be especially helpful given the highly technical nature of NASA missions.

Additionally, teachers called for **more collaboration among colleagues** between workshop sessions**.** We paraphrase one teacher's comments…

> For future projects, more collaboration among teachers is needed. This teacher cited Google Docs as being an 'on-line' tool that might be used to promote collaboration among teachers/students for both documents and spreadsheets. On Word documents there can be ten collaborators and on Excel as many as 100, according to this teacher who had used Google Docs with his students. Two GEONS teachers plan to discuss its use with fellow GEONS teachers when they next meet again to participate in another NASA project.

THEMIS-Based Curricular Materials—Teachers' Feedback Informs Revisions

Creating teacher guides entails a lengthy process of testing and revisions. Having the ability to work closely with teachers who are actually using these guides in their classrooms can yield enormous benefits by streamlining this process. The GEONS project afforded the THEMIS team with an opportunity to do just this.

This section focuses on how evaluation was used formatively to give the THEMIS curriculum design team critical feedback in the process of designing and improving THEMIS-related materials. The following topics are discussed…

- Communications model
- Teachers' feedback
- NASA closes the feedback loop

Communications Model

Figure 1 provides a visual representation of the communications flow that enabled the THEMIS curriculum design team to revise and improve teacher guides. This team relied on feedback from the GEONS teachers as well as from the NASA Education Product Review Board, represented by blue hexagons.

By implementing activities from the guides, GEONS teachers brought THEMIS-based science into the 'real world' of their classrooms and readily discovered 'what works' and 'what doesn't work' with their students. Then they offered their expert views to the evaluator in intensive telephone interviews conducted in the Winter 2005 and Winter 2006. Data gathered from these interviews were distilled and presented to the design team, who then made curricular revisions that addressed teachers' concerns. Revised materials were then made available to the teachers.

The initial interviews in the Winter 2005 touched on how teachers were using all of the THEMIS-related materials including an array of activities guides as well as ancillary audio-visual materials. The Winter 2006 interviews, however, focused on the original teacher guide developed specifically for the THEMIS program—*Exploring Magnetism on Earth*—with a detailed examination of the efficacy of all 17 activities included within. The next section provides details on how data gleaned from these interviews resulted in an improved educational product.

The THEMIS curriculum design team then submitted revised materials to the NASA Education Product Review Board. All guides were reviewed at least once; some received multiple reviews. The review board was able to provide valuable, external feedback that assisted the design team in finalizing the guides for national distribution on the Web site.

COMMUNICATIONS MODEL

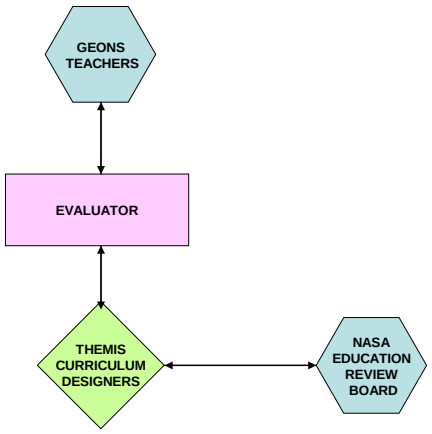


FIGURE 1. GEONS PROJECT—Communications Model. Communications flow for curricular materials revision process.

As the model demonstrates, the curriculum design team received valuable feedback from two critically important sources. GEONS teachers voiced their perceptions to the evaluator who analyzed their insights and shared them with the design team. Additionally, the THEMIS design team dealt directly with the NASA Education Product Review Board in order to gain its insights about the curricular materials.

Another way to understand the curriculum revision process is to present the critical milestones reached. Table 2 describes these milestones with blue bands representing feedback from GEONS teachers and the NASA review team. The tan bands indicate GEONS workshops and the green bands highlight the culminating efforts of the curriculum design team.

THEMIS—GEONS PROJECT Materials Revision Process	
Time Period	**Milestones**
July 2004	GEONS teachers presented with THEMIS-related materials—an array of activities guides as well as ancillary audio-visual materials
January 2005	Evaluator conducts telephone interviews with subset of GEONS teachers to determine their overall familiarity with and use/plans for using THEMIS-related materials
June 2005	GEONS teachers presented with original teacher guide developed specifically for the THEMIS program—*Exploring Magnetism on Earth*—including 17 classroom activities
March 2006	Evaluator conducts telephone interviews with subset of GEONS teachers to determine use and dissemination of THEMIS-related materials—in-depth focus on *Exploring Magnetism on Earth* and the *THEMIS-GEONS Users Guide*
Fall 2006	THEMIS curriculum designers split *Exploring Magnetism on Earth* into four parts—with three guides available immediately and the final guide completed in the Spring 2007
March 2007	GEONS teachers presented with activities from newly-created fourth guide
Summer/Fall 2007	NASA Education Product Review Board reviews activities guides
July 2008	GEONS teachers presented with materials based on student use of magnetometer data including GEONS teachers' presentations and revised *Space Weather* guide activities
Summer 2008	Finalized versions of the four THEMIS-themed teacher guides and Users Guide are available on THEMIS Web site

TABLE 2. GEONS PROJECT—Materials Revision Process. Milestones in the process of evaluating and revising THEMIS-related materials.

Teachers' Feedback

GEONS teachers' feedback was critical to the process for improving THEMIS-related curriculum materials. In-depth telephone interviews served as the vehicle for obtaining this information. While the critical interview for informing curriculum revisions took place in March 2006, about 1½ years into the THEMIS program, an earlier interview in January 2005 provided evidence that GEONS teachers were getting their feet wet with classroom implementation.

The first round of telephone interviews taking place six months into the THEMIS program involved seven GEONS teachers from sites in AK, MI, NV, OR, SD, VT and WI—only four of which had magnetometers at this point in time. Interviews lasted half an hour, on average. Teachers were asked to comment on their use or planned use of various activities guides as well as videos and CDs/DVDs that they had received at the first workshop.

"I am already discussing [with the superintendent] the possibility of dropping the magnetism and electricity portion of my physical science course in order to replace it with the THEMIS project."—*GEONS Teacher*

Teachers were very positive about the guides, noting that the activities provided them with "a simple way to promote student learning." Even at this early stage, a majority of the teachers were planning to incorporate the THEMIS-related materials as an integral part of their basic curriculum. Teachers also noted the importance of the *THEMIS-GEONS Users Guide* in providing them with a solid background in THEMIS-related science. They found other ancillary audio-visual materials valuable and were just beginning to use them in their classrooms.

GEONS teachers made it clear that the quality of these materials was key to the success they were experiencing in bringing THEMIS-related science into their classrooms. In using the materials, however, they were also beginning to detect minor problems inherent in some of the activities. They were making their own changes so that the activities worked better for their students.

"I am looking for a way to teach physics in a non-traditional manner by using all aspects of the THEMIS project."—*GEONS Teacher*

Consequently, it became clear that the THEMIS curriculum development team needed to understand the merits of the activities as they were being rolled out in the classrooms—that is, 'what was working' and 'what needed revision'. The need for this information formed the basis for the next round of interviews conducted a year later.

Interview 2006—A second round of interviewing in March 2006 involved eight GEONS teachers representing AK, MI, MT, ND, NV, OR, SD, WI—eight of the 12 sites that by this time had had magnetometers installed. On average, the interviews lasted 40 minutes.

At this point in the project, GEONS teachers had received the original 17-activity guide *Exploring Magnetism on Earth* as well as formal training for implementing some of these activities. Additionally, teachers were receiving informal guidance and materials via e-mail and a Yahoo! Group on an ongoing basis. Furthermore, the E/PO team encouraged teachers to call them with questions and concerns and held periodic teleconferences to promote sharing of ideas among teachers.

"I had them [students] do the geomagnetism activities and the magnetic field activities. Also the first eight or nine that are mostly magnetism, because I could plug that directly into their curriculum that they were already doing for Physical Science"—*GEONS Teacher*

The focus of the second interview was to examine in-depth teachers' use of the 17 activities in the *Exploring Magnetism on Earth* guide. Two teachers reported having implemented all activities, with five others using anywhere from 18% to 59% of the guide's activities. One teacher—new to the project—was not yet in a position to implement. Additionally, GEONS teachers were asked again about their use of the *THEMIS-GEONS Users Guide.* The purpose of this exploration was to provide the THEMIS curriculum design team with critical data to inform their revision decisions.

Preliminary data from the second round of interviews indicated that GEONS teachers were generally impressed with how well the activities were laid out and that "even if students do something wrong, the activities still work." Teachers were positive about the guide and reported that they selected activities based on what is relevant to or fits into their curriculum.

Anecdotal teacher data produced a clear picture of the strengths and weaknesses of each activity. These data also gave the curriculum design team some teacher-generated modifications for improving activities. The design team embraced the majority of the teachers' suggestions when revising the guide. Moreover, data revealed that the GEONS teachers continued to value the *Users Guide* in bolstering their own understanding of the THEMIS program. Examples of the design team's alterations based on teacher interview data are presented next.

"I decided to use the activities that I used because they fit so easily…It's a little better developed than some of the things you get from other sources."—*GEONS Teacher*

Teacher feedback informs revisions—At this point in the materials development process, it was incumbent on the evaluator to transform anecdotal data from the GEONS teachers into useful summary information to drive revisions of the THEMIS-related activities. The evaluator served as a translator—taking classroom-based ideas from teachers and making them succinct and understandable to the curriculum design team.

After discussions with the curriculum design team, evaluators analyzed teachers' use of the 17 activities in *Exploring Magnetism on Earth*. These usage patterns were taken into consideration by the THEMIS curriculum designers in revising the teacher guide. The data suggest that…

- As subject matter became more difficult, use of those activities declined
- Anticipated or planned use was high for activities dealing with the magnetometer data

In an attempt to understand teachers' implementation experiences more deeply, the THEMIS curriculum designers worked closely with the evaluator examining teacher feedback that illuminated the following key concerns. Data addressing these issues served as a strong foundation for the team's revisions…

- What challenges did teachers experience in using the *Exploring Magnetism on Earth* guide and its activities?
- How was use of each activity influenced by its structure or the way it was written?
- How could each activity be made more usable?
- How compelling was the material?
- How could the material be revised to enhance its interest level for students?

The evaluator also provided the design team with an in-depth analysis of teacher comments for each activity. Teachers offered substantive data for the majority of the activities. The evaluator categorized teachers' concerns into four main themes which the THEMIS curriculum designers subsequently addressed—1) implementation issues, 2) appropriate skill levels, 3) high materials costs and 4) teachers' content knowledge.

Teachers' concerns about **implementation** included difficulties they noted in translating concepts, using materials, making calculations correctly and getting through copious amounts of materials. Remedies for addressing these issues included…

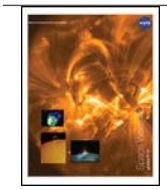
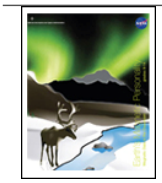
- Renaming activities and creating better segues or introductions to activities
- Working with a teacher experienced in doing an activity to determine if it could be streamlined
- Modifying activities by dividing them to provide focus; introduce elements for clarity
- Adding pictures to the activity or picture gallery on the Web site
- Revising activity to make it more user-friendly; add an answer key

A second area of concern focused on **student skill level—**particularly as it related to activities using the magnetometer data. The curriculum design team incorporated several remedies for addressing these issues. Activities were rewritten to provide appropriate focus to each topic as well as to include more explanations. Additionally, the team worked with an experienced teacher to improve activities' accessibility and to update data used in the activities. It was gratifying to learn that GEONS teachers rated the interest level of their students when doing activities as 'interested'. On average, teachers rated student interest at 3.8 on a 5-point scale ranging from '1-extremely disinterested; bored' to '5-extremely interested-enthusiastic'.

Addressing the third area of concern, **cost of materials**, the team simply advised teachers to submit receipts for expenses. And finally, turning their attention to issues surrounding **teachers' content knowledge,** the team worked to provide more background materials and did some additional creative thinking in order to determine what other changes might be in order.

Apart from providing specific remedies, the curriculum designers reflected on the organization of the guide itself. As a result, one of the most significant changes was made. The 17 activities were broken into four meaningful and manageable segments. Thus, four new guides were created from the original *Exploring Magnetism on Earth*. Three revised guides became available on the Web site in the Fall 2006 and a fourth guide—devoted to the magnetometer data activities—went into the fast track for development. While the activities included in the three guides were easily remedied, the activities involving the magnetometer data required more extensive review and revision and were readied for a Summer 2007 rollout.

The 17 activities of *Exploring Magnetism on Earth* were regrouped into four areas corresponding to the revised teacher guides that are now available on the Web site at http://ds9.ssl.berkeley.edu/themis/classroom.html. Each guide contains an introduction explaining the connection among the four guides as well as a brief explanation of the courses and grade levels for which the guides' activities are most appropriate. These guides include…

Teacher Guides	Content
 *Magnetism and Electromagnetism*	Reviews basic magnetism with four activities exploring magnetism and electromagnetism—used mostly in grades 6-9 Earth and Physical Science classes
 *Exploring Magnetism on Earth*	Includes four activities exploring Earth's magnetism—used in physical science, geology and astronomy
 *Space Weather*	Includes six activities exploring how space weather affects Earth's magnetic field and auroras—used mostly in high school physics and astronomy classes
 *Earth's Magnetic Personality*	Includes six activities directed toward students working with the THEMIS magnetometer data

NASA Closes the Feedback Loop

Once the fourth guide was 'tried out' at a March 2007 GEONS workshop, the THEMIS curriculum design team was in a position to make final tweaks to the activities. With the four guides revised and newly battle-tested, the team handed them over to the NASA Education Product Review Board for final review in the Summer/Fall 2007. The guides passed this review that provided helpful comments for making minor revisions. The THEMIS team made the appropriate changes in accordance with the feedback obtained.

By July 2008, GEONS teachers attending the final workshop were able to try out some of the newly-revised activities—particularly magnetometer activities and those in the *Space Weather* guide. The final versions of the four THEMIS-themed guides along with the *Users Guide* became available on the THEMIS Web site in Summer 2008.

Implementation and Dissemination—Teachers Spread the Word

This section summarizes findings from the final, 'exit' interview conducted with GEONS teachers near the end of the THEMIS program. The focus of questioning was on the program's overall effectiveness with particular interest in how teachers were implementing THEMIS-related materials, how they were sharing these materials with colleagues and what impact they felt the program had had on them and their students. This section is divided into the following topics…

- The 'core' GEONS teachers
- Implementation experiences
- Dissemination efforts
- Deep impact on teachers and students

The 'Core' GEONS Teachers

The beginning section of this chapter discussed all twenty teachers who had participated in the GEONS project at some point during its five-year duration. In contrast, this section focuses on the nine 'core' GEONS teachers who took part in the final, Spring 2009 exit interview. At the time of the interview, all were active GEONS teachers—seven of whom have been in the project since its inception. The remaining two teachers had joined the group within the past two years, but had exhibited a high level of involvement. These teachers represented eight of the thirteen magnetometer installation sites—VT, MI, ND, OR, AK(2), WI and NV(2). The background of these 'core' teachers is best summarized as follows…

- They brought 19 years of teaching experience, on average, to the project
- Most of them had only taught science during their careers
- Their undergraduate majors were mostly in the sciences and physics
- Some held advanced degrees in biology, chemistry and education
- Eight are high school teachers, while one teaches at the middle school level
- They most often teach Earth and space science, physics and astronomy

Reflecting the THEMIS team's goal of reaching underserved, underrepresented students, the 'core' GEONS teachers come from predominantly underserved rural settings including two schools serving significant numbers of Native American or Native Alaskan students. Additionally, this 'core' group reported that 47% of their students, on average, benefit from the federal free/reduced lunch program. Moreover, these 'core' teachers told us that about 75% of their students, on average, were females and non-White/non-Asian males—a group that is typically underrepresented in the sciences.

Despite the fact that several of these teachers come from small schools and districts, during their tenure in the project they estimated that they taught at least 2,720 students using THEMIS-related ideas/materials. This represents an average of 340 students reached by each of the eight teachers who provided this information.

Implementation Experiences

The 'core' GEONS teachers shared information about the ways in which they use THEMIS materials. They also described special technologies/methods they have developed for their students. Finally, they discussed how their instructional abilities with THEMIS-related materials have evolved and how they might continue using these materials once the project ends.

Current implementation—GEONS teachers praised the THEMIS program because it helped them "demonstrate how real science research is conducted." They recognized that their participation in the THEMIS program facilitated teaching science classes in a research-based manner.

All nine of the 'core' teachers reported using THEMIS mission science in their classes. They pointed out that the materials they found most useful included three of the four teacher guides and assorted ancillary NASA materials…

- Teacher guides—*Exploring Magnetism on Earth, Earth's Magnetic Personality, Space Weather*
- The Sun-Earth Connection
- Introduction to THEMIS Program PowerPoint presentation
- Solar Week materials
- Magnetometer data from Web site

The circumstances in which GEONS teachers use the THEMIS ideas/materials are as varied as their teaching situations. For example, some are teaching in very small schools and therefore, teach multiple subjects, often in alternating school years. Some 56% of the teachers reported that they are using THEMIS-related ideas/materials in more than one course. They are also teaching at multiple grade levels.

"THEMIS materials are parts of units that are essential parts of the course so they're built right into the curriculum…We use the activities and guides as a critical part of what's being taught."—*GEONS Teacher*

Questioning teachers about implementation revealed that four used THEMIS materials in astronomy, astrophysics or Earth and space science courses, four had found a place for THEMIS either in physical science, physics or chemistry classes and two were bringing THEMIS into general science. One teacher provided an overview of the program in a geology course and another used THEMIS to demonstrate the practical applications of math. Details of the sites, grade levels and subjects in which materials are incorporated appear below…

Site	Grade Level	Subject
AK	9-12	Geology
	9	Physical Science
AK	8-12	Math
	8-12	Earth Science
MI	9	Earth and Space Science
	10-12	Astronomy
ND	9, 11-12	Chemistry and Physics
	8	Physical Science
NV	8	General Science
NV	11-12	Physics, AP Astrophysics
OR	7-12	General Science
VT	9	Conceptual Physics
WI	11-12	Astronomy

Eight of the 'core' teachers reported that they were integrating THEMIS mission science into their basic science curriculum. They also said that they valued using the materials as a resource, in a supplemental way. They described these additional ways in which they relied on THEMIS materials…

- **N=4** Use Web site to find videos and student research—Look to Web site for video clips, student research using THEMIS magnetometer data in 'real' time, use as 'filler' in science labs
- **N=3** Use all materials to stimulate student interest—Use materials for the 'WOW' factor, to get students hooked on the THEMIS program; use Northern Lights postcard picture as bookmark
- **N=2** Use teacher guides to find appropriate activities—Look to all guides to find activities that are appropriate
- **N=1** Use all materials to find practical mathematical applications—Look to all THEMIS materials for opportunities to find practical applications for math classes

GEONS teachers also indicated that they have been challenged to present the materials to students with wide-ranging capabilities. Teachers mentioned using the materials "in classes that encompass a range of capabilities from Special Education to the highest achievers." One teacher uses THEMIS materials with "students who are considered low-performing and high-risk." At the other end of the spectrum, one teacher has developed an astrophysics course around THEMIS data, making it a full half of the curriculum in an advanced placement class developed for the very highest achievers.

Some of the teachers described special methods/techniques or projects they have developed in order to teach THEMIS ideas. One teacher noted that a thorough reintroduction to THEMIS is necessary to refresh students' minds about the role of the magnetometer, the data it produces and how it is used. Archived data are referenced in this process. In the same vein, another teacher stressed the importance of "ensuring adequate background for THEMIS-related lessons."

One GEONS teacher discussed two 'outside the box' efforts that he had undertaken in order to enhance his students' THEMIS experience. The teacher's first project initially involved the THEMIS team and required making the project's ASCII data useful. The teacher's students were also involved. They were first tasked with downloading the data, measuring magnetic fields at various locations and attempting to detect geomagnetic storms. Methods developed in this project are continuing to be used in the teacher's astrophysics course.

This same teacher reported another interesting application of THEMIS data. The practical final examination in his four physics classes challenged students to use magnetometer data to determine the magnetic field in a certain place, on a certain day. Calculations had to be within a 1% error.

Another GEONS teacher reported that his students receive extra credit for contacting scientists working on THEMIS or other NASA missions. He also assigns open-ended astronomy projects where students can choose to study whatever topic they like. For example, one normally shy, Native American student selected a project on auroras. The student "did a good job on the project" and convinced several other students to select THEMIS-related projects as well.

Implementation evolves—During the five-year GEONS project, some 'core' teachers noted only subtle changes in their implementation practices, while others pointed to dramatic shifts in the ways in which they use THEMIS ideas/materials in their classrooms. Regardless of the extent of these alterations, all GEONS teachers anticipated that they would be implementing THEMIS materials far into the future.

Some of the most dramatic changes, as noted by five 'core' teachers, revolve around their increased facility in using and incorporating the THEMIS materials. One teacher proudly pointed out that her initial dependence on the *Users Guide* for background information about the THEMIS program had ceased because of her growing familiarity with the materials. This same teacher noted that her increasing understanding of the THEMIS program enables her to cover more material each year—"I guess the better I get at THEMIS, the easier it is for my students to understand…then we're able to get a little more done each year." Currently she reports using all teacher guides. The other GEONS teachers echoed her sentiments with one saying that his use of THEMIS materials has increased as he has "grown more adept at incorporating pieces into his curriculum." He reflected that he has "gained more confidence in his knowledge of the material" and thus is better able to deliver in the classroom.

"My ability to implement THEMIS materials has evolved with my growing understanding of what is being studied, what has been found and what we can do with the data."—*GEONS Teacher*

In contrast, three GEONS teachers reported that over the program's duration, they have not significantly changed the way they implement THEMIS ideas/materials. Their stability seems to stem from their satisfaction with the quality of THEMIS materials. As one teacher stated, he is "satisfied with the materials just the way they were developed." He further noted that "the lab activities reinforce the Earth science and physical science and are fine as is."

Future implementation—Whether or not their implementation practices have remained relatively stable or dramatically changed, all GEONS teachers reported that they are planning to incorporate the THEMIS ideas/materials into new courses and projects and will continue to rely on THEMIS guides and activities. One teacher noted that "THEMIS is going to be a permanent fixture in my curriculum."

"Involvement in the THEMIS program is an awesome experience for me and my students."—*GEONS Teacher*

The future is bright for the continued use of THEMIS-related materials. Having incorporated them into the curriculum and demonstrating a strong reliance on the materials as both resource and supplement, GEONS teachers expressed enthusiasm about myriad plans for the future in which they will incorporate THEMIS-related science…

- Developing projects for geology course
- Developing astronomy course
- Developing project-based science course
- Conducting magnetic field studies
- Using hands-on activities
- Integrating 'Problem of the Week' into calculus-based physics course
- Correlating space math problems to state standards and disseminating/using LISTSERV

Of further note are the efforts one GEONS teacher—a Nevada-based physics teacher—who plans to introduce THEMIS into a freshman-level 'Discovery Science' course. It is the teacher's intention to get students "fired-up" about THEMIS science early in their high school experience in hopes of ensuring their continued commitment to upper-level science and physics. To promote his efforts at stoking students' interest, he has organized a field trip for 14 students to the site of the THEMIS mission at the University of California at Berkeley. Half of the students have already studied THEMIS mission science, while the remainder will be doing so in the coming school year. This example reflects GEONS teachers' excitement about sharing the THEMIS program with their students in new ways designed to capture and hold their attention.

Dissemination Efforts

Despite the fact that implementation, not dissemination, was the THEMIS program's focus, the 'core' GEONS teachers were asked to reflect upon any efforts they may have made to share THEMIS ideas/materials with their colleagues and communities. It came as no surprise that they commendably demonstrated their considerable abilities by extending the reach of THEMIS mission science beyond their own classrooms to fellow teachers, members of their communities and even to the nation.

All nine of the 'core' group said that they are sharing THEMIS ideas/materials with colleagues and all but one described ways in which they have reached out to their respective communities. In both formal and informal settings, eight teachers who provided estimates indicated that all together they shared THEMIS with at least 275 colleagues in a typical year or about 35 teachers each. Only four of the 'core' teachers gave estimates of the number of community members they reach on an annual basis, pegging the number at 300 or an average of 75 community members per teacher.

These numbers do not reflect, however, the extensive reach of media coverage such as local newspapers and television spots featuring THEMIS-related stories from select sites. Of particular note is an interview conducted with the Petersburg, Alaska teacher that was featured on *The PBS NewsHour* (formerly known as *The NewsHour with Jim Lehrer*). First aired May 2007 and re-aired on New Year's Day 2008, this interview focused on the efforts of his 11th grade geology class in assisting NASA's THEMIS mission scientists with data collection. According to Nielsen ratings, *The PBS NewsHour* reaches 2.7 million viewers each night, so it is possible that during these two airings alone, more than 5 million viewers learned about students' direct involvement with THEMIS mission data.

Additionally, the video continues to be available on the *Online NewsHour* Web site as well as the Gallery section of the THEMIS Web site. The GEONS teacher also noted that in June 2008 the *NOVA* Web site's *Science NOW* section linked to *The PBS NewsHour* segment under the category of 'Space Storms'—further evidence of the THEMIS program's expanding reach through media coverage.

Sharing with educators—Eight of the 'core' teachers recounted the formal settings in which they have shared THEMIS materials directly with colleagues and six of them discussed the informal settings in which they do so. Some teachers noted that they had shared THEMIS with colleagues through written media, such as articles for state science teacher association journals and school district newsletters.

"I was letting them know that these opportunities were available, there was information on-line and they could get involved with it with their kids."—*GEONS Teacher*

When asked about formal settings for dissemination, teachers most often mentioned presentations they had made at professional development workshops sponsored by regional and state science teacher associations. They reported that they typically presented more than once annually. Teachers use these occasions to distribute hand-outs, CDs and posters related to the THEMIS program. They also take the opportunity to introduce their colleagues to the Web site. In one case, a teacher noted that he has set up his own wiki site and distributes at these workshops a card with its address. He added, "I direct other teachers to go to this site to download worksheets and other materials."

Within their own schools and districts, teachers are more likely to share materials with their colleagues on an informal basis. While some do so at weekly science teacher meetings, others discussed how they share THEMIS mission science with all teachers within their schools. This practice has led to teachers outside the GEONS project incorporating mission science into classes such as math, elementary science and English/writing. Additionally, one of the GEONS teachers said that he had set up a 12-week course centered on magnetism for a colleague teaching 9th grade science. According to the GEONS teacher, "my colleague's 72-minute periods offer an ideal venue for using activities from the teacher guides."

Sharing with the community—Eight GEONS teachers went into some depth about ways in which they have reached out to their communities. All eight mentioned media exposure including local newspapers, cable stations and national television. Six 'core' teachers mentioned disseminating to the community in informal settings and five in formal settings. Highlights appear below of ways in which word of the THEMIS mission has spread in and beyond GEONS teachers' communities…

N=8 Media

- National network—*The PBS NewsHour* and on National Public Radio
- National cable—HDNet TV filmed magnetometer installation
- Local newspapers and e-newsletters
- Local university—THEMIS-themed flyers distributed at local university library

N=6 Informal presentations

- At public board meetings
- Planetarium partnership sponsors 'astronomy nights' highlighting THEMIS mission
- Amateur astronomers share THEMIS mission with members
- Summer camp venue for sharing THEMIS with campers aged 5-15

N=5 Formal presentations

- To school board members to promote value of THEMIS and ensure continued support
- To local Chamber of Commerce
- To scientific and educational communities at conferences

Deep Impact On Teachers and Students

A measure of the success of the GEONS project can be found in the impact it has had on its teacher and student participants. The 'core' teachers revealed numerous ways in which the project has made a profound mark on their own professional lives as well as the benefits it has brought to their students.

GEONS teachers talked about how being part of the THEMIS program has inspired them and helped them in defining more clearly their career aspirations and in deciding on contining education paths. Their involvement in THEMIS has also led to their participation in other NASA programs/projects. They have further gained from new opportunties to attend conferences and workshops, make presentations in the greater scientifc community, develop innovative classroom activites and collaborate with others in their field of interest.

"Just because of this THEMIS experience, I've become involved in projects at UCLA and Santa Barbara where I can build up my career…the more intellectual side."—*GEONS Teacher*

Eight of the GEONS teachers enthusiastically gave testimonials about how the project has opened doors for them to make career moves or at least to clarify a direction in building their careers…

- Continuing higher education—Program involvement has helped clarify three teachers' desire to return to school to obtain master's degrees in astronomy and physics—one envisions teaching astronomy at the college level, one wants to get back into physics research and one wants to finish a master's degree in applied mathematics
- Furthering career—One teacher had the opportunity to participate in a 2-week UCLA program to collaborate on a research paper in laboratory plasma while mentoring elementary teachers. This experience led to an invitation to a workshop at Santa Barbara's Institute for Theoretical Physics
- Improving curriculum—One teacher was inspired to get involved in a school improvement plan that included changing the curriculum. Used this opportunity to work on incorporating THEMIS- or NASA-related content into the science reading component
- Using THEMIS research as master's thesis—Involvement in project led to teacher using THEMIS-related study for the topic of her master's thesis in science education. The thesis examined the effect that exposure to the THEMIS-based science curriculum has on students
- Reawakening aspirations—One teacher said that THEMIS awakened lingering aspirations to get involved in research on upper atmospheric physics

Nearly all of the teachers can point to involvement in other NASA-related programs thanks to their stint with the THEMIS program. Six GEONS teachers have continued their involvement in THEMIS mission science by becoming part of the Heliophysics Educator Ambassador program. Six of them participated in Goddard Space Flight Center's curriculum development project entitled 'Cosmic Times'. Additionally, these GEONS teachers also mentioned their involvement in the following programs—SOPHIA and NOAO's Research-Based Science Education (RBSE) program. One teacher has also taken on the task of becoming a GEMS presenter at an upcoming event.

Participating in the THEMIS program has afforded opportunities for teachers to collaborate on projects, take part in conferences and create presentations for wider audiences than they may have imagined before. Notably, teachers cited the following experiences…

- Attending week-long nuclear conference—Two teachers reported participating in a week-long nuclear conference for physics teachers sponsored by the Department of Energy at the Idaho National Laboratory
- Doing research/making presentations—Two teachers reported presenting at conferences including one alongside THEMIS scientists in Boulder, Colorado's Laboratory for Atmospheric and Space Physics while another did summer research and presented at an AGU (American Geophysical Union) meeting
- Assisting THEMIS team with data research—One teacher mentioned completing a summer project designed to make the THEMIS program's ASCII data more usable i.e. transferring it to Excel spreadsheets now used by astronomy and astrophysics students

Four GEONS teachers enthusiastically shared how they had personally grown as educators and scientists since they first started the project. Two said they have become 'resources' for their less-experienced colleagues. In fact, one of them noted that he is "now known for teaching hands-on science within his school"—he has become the 'go-to guy.' The other teacher explained that although his specialty is actually chemistry, other teachers have turned to him for making THEMIS-related presentations to their students and for answering students' THEMIS-related queries.

GEONS teachers also provided copious anecdotal data reflecting the positive impact that THEMIS-related science has had on their students. 'Inspired' is the word that is most often used to explain this effect. Teachers also noted that they see increases in the size of their science classes year to year. Interest in their courses seems to have been spurred by students' curiosity about the magnetometer and the prospect of working with 'live' data on a 'real' science program from NASA. "Student attitudes towards science have been positively influenced by their exposure to THEMIS" as one teacher stated.

"In general my students like the THEMIS program. It doesn't matter what topic we're studying, they like the direct tie to NASA."—*GEONS Teacher*

Seven GEONS teachers offered tales of inspiration and aspiration as evidence of the impact of their students' exposure to the THEMIS project…

- Female students seek out career paths in the sciences—One female student, inspired by THEMIS, now pursues geology in a special university program she was asked to enter, in part, because of her THEMIS experiences. Another who "has always wanted to be an astronaut" with aspirations for entering the U.S. Air Force Academy has realized that there are additional avenues to pursuing a career in the sciences

- Native Americans/Alaskans respond to THEMIS science—One Native American student produced a stand-out, award-winning project on auroras doing all research on her own. She really "gets it". She also persuaded fellow-students to work on THEMIS-related projects. Several Native Alaskan students have changed their course of education—they now want to go to college citing THEMIS-related science as their inspiration
- THEMIS project opens doors for students—Two students cited their work with THEMIS data in their applications for MIT and Caltech internships—teacher believes the 'ASCII project' gave them an edge at acceptance
- THEMIS science expands students' horizons—Students who enter science courses with little interest in the subject get 'turned on' by THEMIS-related science. A special education student has gone on to study geology in college having been inspired in an astronomy class by engaging in "hands-on" experiences with THEMIS science

Five GEONS teachers offered additional evidence of the positive impact of THEMIS on their students…

- Awarded for work in THEMIS-related science—Student took first place honors as 'Best Individual Forecaster' in George Mason University's First Annual National Space Weather Forecasting Contest. Student used his high school's magnetometer data. His school's team was honored as 'Best Forecasting Team'. Other students in the GEONS network participate in similar contests.
- Increases in science class sizes—Sizes of classes continue to increase year to year in geology and astronomy
- Improved student attitudes toward science—In addition to one teacher's observation of improved attitudes, another teacher provided concrete, measureable evidence she gathered in pre/post assessments as part of her master's thesis
- Improved student attitudes about their own capabilities—Students' attitudes about their own capabilities as well as what they might be able to achieve have been impacted by THEMIS involvement—now students believe they not only can go to college but also can win scholarships to do so
- Draws Native Alaskan students into science—Students who first encountered the Northern Lights in stories and legends from their rich oral traditions are now aware of the scientific explanation for the occurrence of this phenomenon
- Turns students on to work on 'real' science—Students are excited by and appreciate working with 'live' data—they get to see the application of math problems to an actual research project; they get to participate in 'real' science

Key Factors for Success—GEONS Addresses NASA's Goals

In evaluating proposals, NASA considers four critical elements or goals to be addressed by programs seeking funding—their intrinsic merit, relevance to NASA objectives, cost and program balance factors. What do these goals mean? How must programs be structured to ensure that these goals are addressed? The Science Mission Directorate provides guidance about the meaning of these four elements in the form of 'subfactors' that clarify what should be considered. A summary of 'what NASA is looking for' is outlined below…

Intrinsic merit	• **Quality, scope, realism and appropriateness**—Have a clear linkage to SMD's science technology, clearly organized, consistent with requested budget, have clear lines of management responsibilities and demonstrate high probability for successful implementation • **Continuity**—Draw from audiences with demonstrated interest in NASA and connect participants to next level of engagement • **Partnerships/sustainability**—Leverage and achieve sustainability…key aspects are replicable, scalable and can continue beyond NASA's initial funding period • **Evaluation**—Document outcomes and use metrics to demonstrate progress toward goals
Relevance to NASA objectives	• **Customer needs focus**—Designed to respond to a need identified by the education community, a customer or customer group • **Content**—Use NASA content, people or facilities to involve students, teachers and/or the public in NASA STEM
Cost	• **Resource utilization**—Demonstrate an effective use of funds within the adequacy, reasonableness and realism of the proposed budget
Program balance factors	• **Pipeline**—Attract diverse populations to careers in STEM through use of NASA Earth and space science, projects and products • **Diversity**—Reach identified targeted groups through use of NASA Earth and space science, projects and products contributing to the involvement, training and/or understanding of underserved and/or underutilized groups in STEM

An examination of how each component of the THEMIS program reaches these goals offers a framework for summarizing program impact. What follows in the remainder of this chapter is a look at the GEONS project as it reflects NASA's goals. Moreover, at the end of the next three chapters, THEMIS components are discussed with regard to the goals/objectives of NASA.

GEONS intrinsic merit—The GEONS project has brought and continues to **bring NASA into the classroom** in a very 'real' way. It offers a unique opportunity for students to participate in the THEMIS data collection experience by placing magnetometers at or near schools. Students feel connected to THEMIS mission science not only because they can see a physical reminder of the project in their schools' magnetometers, but also because they work with 'real-time' NASA data.

GEONS teachers have been quick to move to the next level of engagement—demonstrating the project's **continuity.** GEONS teachers' deep interest in NASA is evidenced by their participation in other programs. As mentioned previously they have become involved with Goddard Space Flight Center's Cosmic Times project and the Heliophysics Educator Ambassador program.

The THEMIS E/PO team built **strong partnerships** with superintendents and principals at all 13 magnetometer sites. These connections helped to ensure quick replacement of GEONS teachers when attrition occurred. Additionally, these partnerships have promoted strong administrative support of GEONS teachers in allowing them freedom to implement THEMIS-related, inquiry-based science in their classrooms.

The **sustainability** of THEMIS is guaranteed not only by the presence of a Web site, but also by the GEONS teachers' intention to continue using THEMIS ideas/materials into the future. They are planning new courses and projects, looking forward to teaching subjects in which they will be using THEMIS mission science and continuing to use the guides and activities. As one teacher noted, THEMIS "is going to be a permanent fixture in my curriculum."

Throughout the five-year project, GEONS teachers have provided both formative and summative **evaluation** information. They have repeatedly filled out questionnaires and participated in in-depth telephone interviews. They have shared their own perceptions of the program as well as providing both measureable data and anecdotal evidence of the projects' impact on their students. This report summarizes the data gleaned from this extensive evaluation effort.

Evidence of this evaluative effort lies in the striking impact that it has had on teachers and students alike. GEONS teachers have been inspired by the program to redefine their career aspirations and to continue educational pursuits. With regard to their students, teachers noted increases in science class size, improvements in student attitudes towards science and about their capabilities. Most of all, students were excited about working with 'live' data and seeing the application of mathematics in 'real' science research projects.

GEONS relevance to NASA objectives—The GEONS project has focused on **meeting the needs** of middle school and high school science teachers by developing standards-based, THEMIS-related materials that are easily integrated into the basic curriculum. GEONS teachers not only 'tried out' the materials in their classrooms, but also offered valuable feedback from their experiences 'in the field.' The critical role that GEONS teachers played in the revision of the original teachers' guide resulted in the THEMIS team's delivery of a superior educational product—a series of four teacher guides that have been shown to be effective in classroom settings.

NASA **content** for the GEONS project not only brought the placement of magnetometers at 13 schools across the country, but also made THEMIS mission science accessible to teachers and students. Space scientists intimately involved in the mission served as presenters at professional development workshops and mingled with the teachers in informal settings at these workshops. They were available by phone and e-mail to discuss the project with teachers and their students. Consequently, space scientists' expertise in THEMIS science was easily tapped by the GEONS project participants.

GEONS cost—Mindful of the need to effectively **utilize resources** as well as the time constraints experienced by classroom teachers, care was taken to offer workshops in connection with meetings of national science associations or offer exposure to scientific 'extras'. Workshops were held in locations that afforded opportunities to participate in field trips that expanded teachers' horizons. GEONS teachers, for example, were able to tour the National Center for Atmospheric Research and Chabot Space and Science Center in connection with their workshops.

GEONS balance factors—Anecdotal evidence points to the strength of the **pipeline** that the THEMIS program is developing through the GEONS project. Teachers have noticed that some of their female students are now seeking out career paths in STEM. They reported that some of their Native Americans/Alaskans have been inspired by THEMIS and as a result are changing their future plans by going to college. A few students have cited their work with THEMIS-related science as their reason for applying for MIT and Caltech Internship—they feel they have an edge in being accepted because of the scientific work they have done with THEMIS.

Reaching the underserved, underrepresented populations in science has been a hallmark of the GEONS project. As noted, some female and Native Americans/Alaskan students have been positively impacted by the project. It has inspired them and encouraged their aspirations in STEM. Placement of the magnetometers in primarily rural, underserved communities helped achieve the **diversity** seen among the students touched by the GEONS project—those who are now benefitting from their exposure to THEMIS-related science.

PART 2: FORMAL EDUCATION—GEMS SITE LAUNCH

The second formal education component of the THEMIS E/PO program was the launch of a new GEMS site in Carson City, Nevada. The purpose of the site is to support teacher professional development in math and science and to provide resources for teachers in these subject areas. The THEMIS team partnered with the Berkeley-based Lawrence Hall of Science (LHS) in 2005 to create the new GEMS Network site at the Carson City School District in Carson City, Nevada. The highlight of this site launch was a two-day teacher professional development workshop.

GEMS (Great Explorations in Math and Science) is a proven resource for excellence in inquiry-based mathematics and science with guides used nationwide from preschool through eighth grade. To support the growing number of teachers using GEMS materials, LHS maintains an international network of over 65 sites and centers offering professional development and a variety of other teacher services—see figure to the left.

Carson City was selected as a GEMS site because it—1) satisfies the conditions for being a prime candidate for E/PO magnetometer installation and 2) affords an opportunity to tighten the already strong ties between the THEMIS and GEMS programs.

Carson City was an excellent prospect for magnetometer installation due to its remote location. Moreover, it met the needs of the THEMIS program by offering an abundance of underserved school districts including those on tribal lands.

The site launch and associated workshop provided further opportunity for the THEMIS program to collaborate with Lawrence Hall of Science's GEMS Network. This union is exemplary of the many working partnerships that the THEMIS team nurtured throughout the grant period.

Beyond the immediate THEMIS/LHS partnership, the maintenance of the Nevada site requires strong local support. This support ensures the site's sustainability. It comes from a network of Nevada personnel including a GEMS Associate who serves as the site Lead, the school district's assistant superintendent, the Nevada state science coordinator and the director of the new observatory at a nearby community college. The magnetometer is installed on the grounds of this local college.

The site launch took place in conjunction with a two-day teacher professional development workshop emphasizing Earth and space science as well as the physical sciences. Eleven sessions were held—three for all participants and eight serving as break-out sessions where participants had a choice of attending sessions for lower or higher grade levels.

GEMS FAST FACTS

- ☼ *2005 GEMS site launch in Carson City, NV marked the beginning of what continues today as an independently operating site that uses district funds, fees and grants to support its work, while at the same time maintains contact with LHS*
- ☼ *The site launch provided a two-day, extensive workshop experience to 42 elementary and middle school teachers, primarily from Nevada*
- ☼ *Participating teachers were predominantly from underserved, underrepresented districts with almost half being rural locales*
- ☼ *Workshop participants reported having the potential to expose 3,500 preK-8 students to GEMS materials/ideas*
- ☼ *One-third of these students represent minorities*
- ☼ *Workshop participants reported having the potential to share GEMS materials/ideas with 1,500 colleagues; our three case study teachers alone shared GEMS with 150 colleagues*
- ☼ *Some 180 teachers have participated in site workshops in the first three years after the launch*
- ☼ *150 teachers are on a LISTSERV and Google group associated with the GEMS site*

The evaluation plan for the GEMS site launch and workshop called for the collection of data from both workshop participants and the site Lead. These data were gathered at both the 2005 workshop as well as two years later and used the following methods—1) end-of-workshop questionnaires for teacher participants, 2) follow-up telephone interviews with teacher participants and 3) an in-depth telephone interview with the site Lead.

Data from these sources are summarized in the following sections…

- Participating teachers
- Workshop findings
- Long-term impact
- Key factors for success

Participating Teachers

The Carson City GEMS Network site serves teachers in northern Nevada—many of whom are in remote and underserved districts, including ones on tribal lands. A total of 42 teachers attended the two-day workshop associated with the site launch. The vast majority of these teachers were from Nevada. They were accompanied, however, by five GEONS teachers who had just completed a week-long GEONS workshop in Carson City.

Of the 42 teachers, 38 completed the end-of-workshop questionnaire revealing information about themselves and their teaching environments. Reflecting the fact that GEMS curriculum focuses on grades K-8, a picture emerges of an experienced group of elementary and middle school teachers. Not surprisingly, most indicated they were either incorporating science into their curriculum or specializing in teaching math or science in underserved rural or suburban communities. Finer details of the picture are summarized as follows…

- These veterans have spent an average of 17 years in the teaching profession
- Most teach grades pre-K through 8—63% pre-K and elementary and 26% middle school
- 46% teach general elementary courses incorporating science and 41% specialize in math or science
- Almost four-fifths teach in non-urban locations—46% rural, 33% suburban
- 47% of their students are female and 33% represent minorities

These teachers offered a variety of reasons for attending the workshop. Over a third (37%) explained that the key motivator for participation was their familiarity with GEMS materials/guides. Almost a quarter (24%) was drawn to the workshop because they were seeking new materials and ideas for classroom instruction. Other reasons for attending—their colleagues encouraged their participation, the workshop provided an opportunity to earn certification credits as well as being convenient in time and location and participants had an interest in inquiry-based instruction, a love of science and a desire to share knowledge with students/colleagues.

"I have several GEMS guides and think they are very well written and explain concepts very well."—*GEMS Teacher*

Reporting an average of 92 students each, workshop participants could directly expose a minimum of 3,500 students to GEMS materials. They also reported that they could share these materials/ideas with about 39 fellow colleagues, on average, or a total of almost 1,500 fellow teachers. These figures bode well for workshop participants to reach large groups of students and colleagues, if indeed they return to their workplaces with well-honed skills and high enthusiasm for implementing and disseminating what they have learned.

Workshop Findings

The two-day workshop provided an overview of what the Carson City GEMS site offers—an introduction to GEMS guides and videos, a description of the role of the site and details about the site's services. GEMS-based and THEMIS-themed presentations, however, were the workshop's main attraction. Over the course of the two days, eleven presentations were available to teachers. Presentation names and appropriate grade levels are summarized below…

	Day 1 Presentations	Grade Levels		Day 2 Presentations	Grade Levels
	Oobleck: What do Scientists Do?	**4-8**		**Build It! Festival**	**K-6**
OR	Sifting Through Science	K-3	**OR**	Terrarium Habitats	K-6
	Mapping the Magnetic Field	4-8		Electric Circuits	3-6+
OR	Investigating Artifacts	K-6	**OR**	Buzzing a Hive	K-3
	Living with a Star	6-8		Stories in Stone	4-8
				Microscopic Explorations	**4-8**

All teachers were expected to attend the sessions in bold—'Oobleck: What Do Scientists Do?', 'Build It! Festival' and 'Microscopic Explorations'. Twice daily teachers were offered break-out sessions where they were free to go to whichever sessions met their interests, needs and grade level requirements. Two selections were available for the morning and afternoon spots on each day. The two sessions in red were devoted to THEMIS-related materials/ideas.

At the conclusion of the workshop, teachers completed questionnaires designed to reveal the information summarized in this section…

- Understanding and using GEMS materials
- Improving the workshop
- Using the Carson City GEMS site

Understanding and Using GEMS Materials

Teachers were asked to rate their understanding of workshop presentations, their prior and anticipated use of GEMS and THEMIS materials and their expected 'comfort level' in implementing and disseminating materials. They were also asked to discuss any barriers they felt might interfere with their using these materials.

Clarity of presentations—Using a 4-point scale ranging from '1=Not clear at all' to '4=Very clear', teachers were asked to rate how clearly they felt they understood workshop topics. All presentations rated solidly between 'clear enough' and 'very clear' with mean ratings ranging between 3.3 and 3.9.

Topics deemed appropriate for students at higher grade levels proved to be among the more challenging to understand. Four presentations, registering mean ratings in the 3.3 to 3.5 range, were appropriate for Grade 3 and above and included both THEMIS sessions. Since the GEMS workshop was predominantly a group of elementary teachers, they may have found the content of these sessions more complex and less applicable to their students than materials intended for pre-school and lower elementary grades.

Use of materials—Teachers attending this workshop were no strangers to GEMS and other inquiry-based curricula in science and math. They estimated using inquiry-based instruction 48% of their class time, on average, with responses ranging from 10% to 90% of the time.

Fifty-five percent of the attendees reported using GEMS units prior to the workshop, while 66% said that they had used inquiry-based units other than GEMS. The majority mentioned using LHS's FOSS. They also reported instructing with self-generated labs, activities and science kits as well as activities from the AIMS Foundation.

Teachers were asked to indicate on a 5-point scale how likely they were to implement the topics presented—where '1=Will not use' and '5=Certain to use'. All topics garnered mean ratings in the range of 3.4 to 4.6—solidly in the 'somewhat likely to use' to 'very likely' to use range. Although teachers had indicated they were somewhat more challenged by presentations directed to Grade 3 and above, this did not seem to deter their plans to implement these topics. For example, the THEMIS presentations which teachers had found among the most challenging to understand were nonetheless among the most likely to be used in their classrooms.

Teachers anticipated implementing GEMS materials and ideas in multiple ways. Two-thirds indicated they would use the materials as a resource or supplement in science, while almost three-fifths (58%) expected to use them as part of their basic science curriculum. Teachers also mentioned using the materials for tutoring and in after-school clubs.

In a nod to dissemination, half of the teachers planned to use these materials to train colleagues in both formal and informal settings. A few of the teachers anticipated sharing the materials in graduate classes and at conferences.

Perceived ease of implementation/dissemination—Teachers anticipated that they would be equally comfortable presenting THEMIS materials/ideas to students as well as to colleagues in informal settings. They indicated, however, that they would be less confident sharing with their fellow teachers in more formal settings.

About a fifth (21%) of the teachers noted that lacking confidence in their own abilities served as a barrier to making presentations at conferences/workshops. One teacher suggested that "watching a model teacher in my classroom first" might ease fears.

Other potential barriers to disseminating materials/ideas included time constraints (42% of the teachers mentioned this), resistance from colleagues/district administrators (27%), emphasis on non-science courses and methods other than inquiry-based (24%) and lack of materials or storage space (15%). On the plus-side, 9% said no barriers were foreseen as inquiry-based instruction was already being done.

Improving the Workshop

Eighteen of the 38 participating teachers offered multiple responses to an open-ended query about improving the GEMS workshop. By far, positive comments about the workshop outstripped all others. Nearly three-fifths (56%) of the teachers gave commendations to the workshop leaders and praised the material presented. Comments such as "very nice job!" and "loved the presentation choices" indicated overall satisfaction.

"It was well thought out, minute details attended to, instruction great, terrific to be involved in."—*GEMS Teacher*

Only a little over a fifth (22%) of the teachers offered suggestions about presentations and materials. This small group called for coverage of more activities rather than in-depth examinations of a few activities. One teacher recommended getting a "taste of many activities rather than doing each activity in-depth." Regarding materials, another teacher noted that it "was great having all the guides on hand for us to browse" and suggested "having some on hand for purchase without shipping and handling would be a nice benefit and an incentive to purchase now."

Seventeen per cent of the teachers suggested having more time to explore materials/activities and to interface with their colleagues, 11% requested more 'creature comforts' at the workshop venue and 6% felt that presenters should use more advanced technology.

Using the Carson City GEMS Site

Teachers' involvement with the Carson City GEMS site need not end with the conclusion of this professional development workshop. The site remains available to provide a wide range of support and services to educators, including additional professional development opportunities. In an effort to determine the extent to which teachers planned to take advantage of all the site offerings, an open-ended query probed their intended future use of the site. It asked them how they anticipated that the site might assist them in feeling more knowledgeable about GEMS topics and more comfortable in presenting them to students/colleagues.

Thirty-two of the workshop participants offered multiple responses indicating that they were 'tuned in' to the message that the site is there to provide them with support. Teachers most often said that they would look to the site for training assistance (50%) and resources (47%).

"I will look to the GEMS site for contacts, to check out materials/resources and for moral support. I will also attend more leadership trainings."—*GEMS Teacher*

Teachers were excited about the prospect of being able to attend more leadership trainings at the site and having the site's Lead in such close proximity. They anticipated that it would be easy to get their questions answered with an 'expert in residence'. Furthermore, they could foresee the availability of materials and resources as a welcome convenience—commenting that "the GEMS site will be a great resource for finding information, borrowing kits and materials for workshops" and "it's nice to know that kits are available to present to staff and allow them to experience the activities."

"Knowing that I can come, check out materials for training teachers so that I do not have to put it together myself is a great assistance."—*GEMS Teacher*

Ever eager to collaborate, 28% of the teachers hoped that the GEMS site could facilitate connections with other teachers. They noted that access to the site would lead to being able to "communicate with other teachers doing the same thing" and saw the potential for building a network of colleagues.

Long-term Impact

Over time, the Carson City GEMS site has become a shining star in the constellation of the GEMS network. Since its launch, the site has been operating independently and is sustained by district support as well as state and local funding. The site also maintains close contact with the Lawrence Hall of Science. Through the tireless efforts of a committed and resourceful Lead, the site has sustained itself since its 2005 beginning. This section presents select highlights of the site's ongoing and planned activities as well as its impact on teachers, featuring case studies of three attendees from the inaugural workshop.

GEMS Site Supports Teachers

By 2008, the Carson City GEMS site had a three-year history of supporting Nevada's teachers with resources for teaching elementary and middle school science. Seeking an overview of the site's activities, the evaluator conducted a telephone interview in June 2008 with the site's Lead. Responsible for directing the site's activities since its launch, the Lead was well-positioned to reflect on its impact.

The interview centered on how the GEMS site has supported the science teachers of Nevada. Findings include a summary of workshops conducted and the availability of science kits, additional support and services provided by the site and a look toward the site's continuing work. Throughout the narrative, the challenges faced by the site as well as its achievements are revealed and the benefits of the THEMIS/GEMS partnership becomes evident.

Workshops and science kits—A large geographical area, predominantly rural, with dispersed populations and encompassing some tribal lands all present challenges for reaching teachers served by the Carson City GEMS site. Despite these difficulties, the site has been successful in providing professional development opportunities to Nevada's far-flung teachers and making science guides and kits available for their use.

In the first three years after the GEMS site launch (2005-2007), approximately 180 teachers have participated in workshops. Workshop attendees represent 11 counties in Nevada and Truckee, California—considered part of the region served by the Carson City site. Of the original 42 teachers who attended the GEMS site launch, a cadre of 25% has continued to attend subsequent professional development sessions. Summer workshops in Carson City went on hiatus in 2008 due to school construction and delayed funding.

Prior to 2008, available funds were sufficient to allow the GEMS site to 'take the show on the road'. Renting a van in the Summer 2006, the Lead made the six and a half hour drive to a rural area to present a two-day workshop. She was accompanied by a GEMS Associate—an active professional development presenter trained by LHS's GEMS program. Drawing 18 teachers from rural areas, the workshop presented inquiry-based science curriculum to teachers who could not travel from their remote locations to Carson City. In the same month, the GEMS Associate also conducted a workshop, bringing another 15 rural teachers into the fold.

"The teachers were most grateful to have the workshop in Elko because normally they would have to go to Reno or Salt Lake City."—*GEMS Site Lead*

Each teacher leaves the workshop with GEMS guides, receiving anywhere from two to six guides. For teachers wanting more, the site maintains two complete sets of GEMS guides—one for teachers to check out; the other for professional development use. These complete sets are housed at the GEMS site which is located at the Carson City middle school.

Teachers can check out science kits, also housed at the middle school. Eighty science kits are available for teacher use, while 20 are retained for professional development workshops. An inventory list and procedures for checking out the kits have been mailed to workshop participants as well as to all school districts in the state. This information is also available on the Web. The GEMS site Lead noted that few kits were checked out in the first year of operation. However, as teachers attend post-launch workshops and become comfortable teaching inquiry-based science, more kits have been checked out and are in the field. She observed that locating the kits, or perhaps the GEMS site itself, in a more prominent location might increase their use—she suggested a venue such as a professional development center that "gets a lot of foot traffic."

Truly motivated teachers, however, have not been deterred. The Lead tells of one teacher who makes a thirteen hour round-trip to Carson City a couple of times a year to check out kits. Since teachers are coming from such long distances, they typically stop in to check out and drop off kits when they have other business in Carson City. The Lead notes that it is not uncommon for teachers to keep a kit for as much as three months, which is not a problem as long as no other teacher is asking for that kit.

In order to keep in contact with such widely-dispersed teachers, the Lead developed a database with critical contact information on teachers who have attended sponsored workshops, have borrowed science kits or have otherwise been in contact with the site. The list has grown to more than 150 teachers. In an effort to reach all teachers automatically, a LISTSERV and Google groups have been set up. The Lead also maintains communications with teachers by preparing and distributing a newsletter.

Additional support and services—Workshops and availability of science kits are supplemented by a number of additional activities and services provided by the Carson City GEMS site. The Lead personally offers assistance in the following ways…

- Connects teachers new to using GEMS with trained and experienced teachers
- Provides guidance to teachers by telephone
- Assists teachers during site visits

Additional professional development activities conducted in association with the GEMS site include…

- A 9-week course—offering two continuing education credits and two GEMS guides
- GEMS-based classes in multiple rural areas
- A pilot program in GEMS-based literacy

The Lead shared the story of her work with a teacher who is using GEMS science kits for language acquisition as well as instructing other teachers in her methods. Her novel approach of weaving science into language arts promises to expose many students to science in districts where core subjects are emphasized more than science. The Lead also described her assistance to three Carson City middle school teachers who are doing GEMS Space Sequence testing. Being at the same school makes it "easy for them to compare notes."

The work continues—Being singly responsible for maintaining the work of the GEMS site, the Lead does not rest on her laurels. As an independent and self-sustaining entity, the search for site funding continues on an annual basis. While grateful for the support of the Carson City school district in providing space for the site's resources, options for garnering additional support are regularly explored.

One such exploration has led to discussions with administrators at the community college where the GEONS magnetometer is housed. These talks began with the idea of incorporating a technology component into the GEMS curriculum. These initial ideas gave birth to a collaborative proposal for leveraging the college's teleconferencing system so that GEMS classes could be offered throughout the state.

The Lead has also made a concerted effort to cultivate relationships throughout the state. For example, whenever she learns that a district has hired a new superintendent, she makes contact. In fact, one of the superintendents, a former science teacher, attended a workshop to experience first-hand the GEMS inquiry-based curriculum. In addition, the Lead has taken advantage of contacts that she has made through training opportunities in order to partner with other groups/organizations that are looking for fresher teaching materials. According to the Lead, such contacts are apt to bring "a bunch of new converts".

The Lead is quick to point out the benefits of having partnered with THEMIS E/PO. She acknowledges that through this partnership another ATLAS grant was obtained, thus allowing the site to reach even more teachers with space science curriculum. The site has also benefited from the extensive contributions of one of the GEONS teachers who was introduced to GEMS through the launch.

After the Site Launch

The 2005 GEMS site launch workshop offered teacher training in GEMS units and THEMIS-related science. The workshop was billed as a 'leaders' workshop. What does this say about teachers who attended and what was expected of them after the launch?

In general terms, 'GEMS leaders' are educators who are GEMS users and share what they know about it with other teachers. The GEMS project views the 'leaders' designation with flexibility and in their own words say that GEMS leaders are "leaders in their field who are knowledgeable about GEMS." Consequently, site launch participants could indeed be considered 'GEMS leaders.' More than half had been using GEMS prior to attending the workshop and indicated that they would be very likely to use workshop topics and activities once they returned to their classrooms. Furthermore, they said they would be comfortable in sharing what they had learned with their colleagues in informal settings.

For educators who desire to take their commitment 'to the next level', the GEMS network staff offers additional intensive training culminating in a certificate acknowledging this training and a title change from 'leader' to 'Associate'. GEMS Associates are avid users of the GEMS curriculum and active presenters of GEMS professional development opportunities.

Data revealing the long-term impact of the initial GEMS workshop were gathered in in-depth interviews approximately a year after the launch. We present these findings from two perspectives. First, from the viewpoint of the Lead who continues to maintain close contact with many workshop participants, we present 'Where are they now?' snapshots of some of the inaugural workshop attendees. Secondly, from workshop participant interviews we present select case studies of three exemplary teachers who went on to blossom as GEMS leaders.

Where are they now?—The GEMS site Lead notes that teachers who attended the initial workshop have been very mobile. Not only have they moved from district to district, grade level to grade level, but also they have transitioned out of the classroom into professional development and administrative positions. Additionally, at least five launch attendees have either retired or moved to another state.

"I am aware of elementary teachers who are now teaching science who were not teaching it before."—*GEMS Site Lead*

This mobility, however, does not spell the end for their involvement with GEMS. In fact, movement of GEMS leaders, particularly into administrative positions, bodes well for continued support of the inquiry-based curriculum. As the Lead notes—"it is great to involve principals in GEMS, because they really assist us." These are the people who "give their permission" to use GEMS units.

One of the launch teachers is now director of curriculum development for Reno's school district and has shown great interest in the GEMS site. She and her spouse, a professor of teacher education at a local university, have collaborated on a request to the school district to obtain GEMS science kits for teacher training in the Reno area. Another workshop participant who is a vice principal extends the reach of GEMS well beyond the classroom. On an annual basis, she uses GEMS in her county's Science Night. The event is open to the entire community and features science fair award presentations in addition to GEMS activities.

Even teachers who stay in the classroom year after year remain "pro-GEMS" according to the GEMS site Lead and "push it wherever they can." She stresses that even when teachers move from teaching one grade level to another, they typically continue to use GEMS. For example, one teacher who started using GEMS at the Kindergarten level has transitioned to the second grade and continues to use "GEMS all the time." All of these teachers certainly exemplify educators who are 'leaders in their field' who are 'knowledgeable about GEMS.'

What follows is an in-depth look at what has happened in the professional lives of educators who attended the GEMS site launch workshop. We offer profiles of three select 'GEMS leaders'—one of whom is a GEMS Associate.

Teacher-trainer—This educator is a teacher trainer in all subjects (K-12) in a rural, Nevada county with only 1,000 students scattered throughout a large area. Describing her continued involvement with GEMS and dissemination to colleagues, she reports reaching 30 teachers. Highlights of her efforts are summarized as follows…

- Publishes newsletter—Prepares and distributes to teachers a newsletter featuring GEMS activities
- Models lessons—Models lessons in the classroom; demonstrating how to use GEMS guides and sometimes featuring THEMIS-related activities
- Assists in program development—Assists teachers in developing programs for their students incorporating GEMS materials

This teacher trainer is a fan of using the traveling kits. They are particularly handy considering that the county she covers is so geographically spread out. She praises GEMS activities because they "always work" and have a "nice little hook to engage the kids." She notes that the 'debriefing' section connects content with the activity, thus making the activity "more than just fun."

This teacher trainer provides anecdotal evidence of students' successful engagement with GEMS. On numerous occasions, "parents have called the school to get the materials list and instructions for various GEMS activities that their children have done at school." Students come home, tell their parents what they have done at school and "want to do the experiments at home." Parents appear to be quite happy to oblige their children's eagerness to duplicate their inquiry-based learning experiences.

Middle school teacher—This profile of a GEMS leader features a middle school science teacher who attended the GEMS launch and has since actively incorporated GEMS into her curriculum and that of her colleagues…

- Has been teaching science for 14 years
- Has a main interest in life science, but has also taught physical science
- Reaches 130 students each year with GEMS science

This GEMS leader teaches in an urban Nevada setting with a 40% minority student population. In a unique collaborative effort, she works in a team with two other teachers to present history, English and science to middle school students. This approach allows for integrating writing into science, for example. Her efforts at implementing/integrating and disseminating GEMS materials reveal that she has already begun to achieve incremental success.

In the school year right after the GEMS launch, her school district mandated less structure in the basic curriculum and proved to be fertile ground for using the inquiry-based GEMS learning guides. Using 'Bubble-ology', for instance, to teach scientific method, observation and data collection, she noted that students "liked these GEMS materials" as did she. She believes "that kids are better off for learning with this inquiry-based approach." She likes that GEMS materials promote "critical thinking."

"GEMS materials helped me do inquiry better…I feel more comfortable doing guided inquiries with my kids…I had gotten used to using activities that were more structured…I now feel I can be 'looser; and let the kids 'go' a little more."—*GEMS teacher*

The next school year, however, ushered in a movement for strict adherence to the basic curriculum, allowing little time for GEMS activities. She had concerns that her supervisor would not "understand the importance of the GEMS self-exploring materials" and faced hurdles in rationalizing its alignment with the prescribed curriculum. A new principal further complicated integration efforts. Nevertheless, she has convinced the principal to purchase 10 GEMS guides for the school. She views this purchase as a success that portends a bright future for the **integration** of inquiry-based science in her school.

During the same school year, class-size reductions were initiated. Smaller classes proved to be a great benefit for the team approach and offered the GEMS leader new opportunities to **disseminate** GEMS materials to her colleagues. She reported that her teammates eagerly embraced GEMS materials/ideas and quickly began to implement them in their own classrooms. Additionally, the GEMS leader mentored two student teachers in physical science; one of whom has readily embraced the materials. The GEMS leader said that she plans to mentor more student teachers, catching them in their formative years. She considers these young teachers as the very best prospects for the future spread of GEMS materials/ideas within her district's prescriptive environment.

This GEMS leader acknowledges her frustration in dealing with the conflicts that arise in finding time to implement GEMS in the face of being required to teach a basic curriculum. Furthermore, she pointed out the potential for confusion between state standards and the GEMS materials that are based on national standards. Nonetheless, she remains committed to inquiry-based science education and persists in the face of myriad obstacles to implement and disseminate GEMS materials/ideas. She remains "very inspired" and said that she was "honored to have been part of the GEMS launch and meet women scientists working on THEMIS."

GEMS Associate—Our final profile features a middle school teacher who is currently a GEMS Associate, the highest level of involvement for an educator within the GEMS program. She teaches in a rural Nevada county with a student population that includes 27% Hispanics or Native Americans. The highlights of her background are that she…

- Has been using GEMS materials for all 13 years she has been a teacher
- Teaches integrated science using GEMS materials exclusively
- Has been trained to teach in grades K-8 including English, history and general science

Early on in her involvement with GEMS, the Associate worked single-handedly to legitimize GEMS materials in her district/state by mapping GEMS activities into Nevada state standards. Those activities that aligned best were integrated into the curriculum, while those fitting less well were set aside as supplemental resources to be used when time allowed. LHS has since enhanced their Web site to include matrices of the GEMS lessons aligning with standards from select states. Nevada is among the states included.

The Associate likes the fact GEMS is inquiry-based and "very user-friendly, especially for the novice teacher." Moreover, she credits her involvement with GEMS for enhancing her credibility as a science teacher since her undergraduate degree is not in science, unlike most other science teaching colleagues.

With regard to **implementation,** the Associate uses GEMS almost exclusively and as the core of her teaching, despite the fact that her district has adopted three non-GEMS texts to guide the curriculum. She particularly praises GEMS' 'Dry Ice Investigation' that she considers "the best guide ever printed on scientific method, how to write hypotheses, the difference between observation and hypotheses, etc." Since the ability levels and interests of students in her classes change each year, she adapts GEMS guides to meet students' needs and appreciates the suggestions for 'going further' that provide enrichment for gifted students.

The Associate's numerous **dissemination** efforts have involved sharing GEMS materials with more than 125 teachers throughout her career. Her efforts include…

- District-level workshops—she has had a 13-year run of two workshops per year with the same 8-10 teachers at each workshop
- GEMS event—she has interacted with 35-40 teachers at GEMS events
- Two-day GEMS workshop—with funding and supplies from the GEMS site in Carson City, she has conducted a workshop for 15 teachers introducing them to eight GEMS guides

These glimpses into the professional lives of three GEMS teachers demonstrate the high level of involvement that caring, dedicated educators can bring to the GEMS network when promoting inquiry-based science. While the 42 teachers at the launch estimated that they would share GEMS materials/ideas with 1,500 colleagues, these three case study teachers alone 'spread the word' to more than 150 of their fellow teachers—with the Associate reaching 125. According to the site Lead, a new NASA grant has enabled three more teachers to attend LHS' GEMS staff training to become Associates. Based upon the experience of our profiled Associate, this means that nearly 400 more teachers could likely be reached once these new Associates have had a few years in the field.

Key Factors for Success—GEMS Launch Addresses NASA's Goals

As mentioned in the previous chapter, NASA considers four critical elements or goals when evaluating program proposals—their intrinsic merit, relevance to NASA objectives, cost and program balance factors (refer to page 25 for detail). This section discusses how the GEMS launch met NASA's goals and in so doing summarizes the impact of this component of the THEMIS program.

GEMS intrinsic merit—The GEMS launch itself came to fruition through a collaborative effort of the THEMIS team and the LHS GEMS Network. This union is exemplary of the many **working partnerships** that the THEMIS E/PO team nurtured throughout the grant period. The partnership of THEMIS with GEMS proved instrumental in GEONS teachers' introduction to GEMS. One GEONS teacher lent his expertise to perfect the GEMS space science curriculum and contributed as a workshop presenter.

Furthermore, the power of partnerships continues to be felt in the **sustainability** of the Nevada GEMS site. Relationships that the site Lead has forged with the Carson City school district, state science coordinator and local community college yield support that secures the site's future. As an independent entity supported by district, local and state funding, the site Lead not only nurtures these productive relationships in obtaining monies, but also seeks to cultivate even more potentially productive connections throughout the state.

The site Lead's diligence in maintaining contact with educators and GEMS workshop participants also yields dividends. As these teachers move into decision-making positions as principals and curriculum directors, they assume leadership positions in promoting GEMS inquiry-based curriculum and thus ensure its **continuity** and expanded use.

Moreover, dedicated teachers have demonstrated their willingness to take their involvement 'to the next level'. They do this not only by implementing GEMS and THEMIS-related science in their classrooms, but also by disseminating what they have learned to their colleagues. NASA funding is ensuring that at least three more teachers will join the ranks of GEMS Associates in Nevada. The site's Lead is also taking her involvement 'to the next level' by working on ATLAS—a teacher professional development project centered on curriculum that has been developed for several NASA missions.

GEMS relevance to NASA objectives—By partnering with the THEMIS project for the site launch, the GEMS team ensured that the workshop would deliver THEMIS-related science **content** to Nevada educators who attended. This content supplements GEMS teacher guides that are also developed with NASA funding and discuss various NASA missions. Assisted by educators who are associated with the Carson City site, the development of GEMS space science curriculum continues.

Focusing on **meeting the needs** of Nevada teachers, the site Lead not only provides workshops in Carson City, but also has 'taken the show on the road' to reach teachers in the most remote, rural locations. Services offered by the site include connecting novice GEMS users with teachers trained and experienced in using GEMS curriculum guides, providing guidance by telephone and doing site visits to assist teachers. Science kits are also made available at the site for teachers to check out for classroom use.

GEMS cost—The GEMS launch created an ideal opportunity for the THEMIS project and the GEMS program to leverage resources, thus effectively **using resources** to further the goals of each program. The tradition has lived on with the site Lead's efforts to make the most of funding by offering 'bonus' workshops for teachers in remote locations of the state.

GEMS balance factors—Prior to the GEMS launch workshop, more than half of its participants already had some experience with GEMS units. The newly-inaugurated Carson City site provides a unique opportunity not only to expand the reach of GEMS, but also to introduce Nevada educators to THEMIS-related science curriculum. Challenged by a location of remote and underserved school districts including those on tribal lands, teachers served by the site were eager to gain access to NASA mission-related, inquiry-based curriculum for their students. The foundation for developing a solid **pipeline** for continued interest in STEM among underserved, **diverse** populations is clearly being laid.

PART 3: FORMAL EDUCATION—SHORT-TERM WORKSHOPS

"In order to be more effective at training teachers of Native American students, we took part in workshops hosted by Sun-Earth Connection Education Forum on understanding Native American science and culture…these workshops helped the E/PO team to understand NASA's involvement with tribal communities…from the perspective of tribal members."—*L. M. Peticolas, Lead E/PO Scientist*

The third and final formal education component of the THEMIS program consisted of 30 short-term professional development workshops presented to more than 550 K-12 teachers nationwide. They offered some of the same THEMIS-related content that was presented to the GEONS teachers, except that these workshops were one-time events having durations of only one-hour to two days; not ongoing professional development projects like GEONS.

WORKSHOP FAST FACTS

☼ *Throughout the grant period the E/PO team conducted some 30 short-term workshops for 550 K-12 educators nationwide*

☼ *The vast majority of these workshops were done in partnership with other NASA missions and programs—ELISA, FAST, RHESSI, STEREO and SECEF*

☼ *The E/PO team estimates that within a year of the workshop participating teachers will reach upwards of 48,400 students and share THEMIS-related materials/ideas with around 2,200 colleagues*

☼ *A core group of these teachers reported that 68% of their students were underserved minorities in science education*

Primarily, the workshops were conducted at state and national conferences such as the National Science Teachers Association (NSTA) and California Science Teachers Association (CSTA), as well as locally at the Center for Science Education (CSE) at the Space Sciences Laboratory (SSL) at the University of California at Berkeley. The annual Astronomical Society of the Pacific (ASP) meeting offered a venue for a couple of the workshops.

Special effort was made to reach teachers whose students are Native Americans by presenting workshops at such venues as the American Indian Science and Engineering Society (AISES) and the Society for Advancement of Chicanos and Native Americans in Science (SACNAS). The primary aim of SACNAS is to promote careers in science and engineering to underserved minorities, particularly Chicanos and Native Americans. These efforts supplemented those inherent in the GEONS project in which about two-fifths of the magnetometer sites are on tribal lands.

Thirty workshops were conducted from Summer 2003 through Spring 2009. In most cases, presentations of THEMIS-related materials/ideas were made in partnership with other NASA-sponsored missions and programs. These partners included…

- **ELISA** Engaging Latinos In Space and Atmospheric Sciences: Integrated Teacher Professional Development and Community Outreach
- **FAST** Fast Auroral Snapshot Explorer Satellite
- **RHESSI** Reuven Ramaty High Energy Solar Spectroscopic Imager Satellite
- **STEREO** Solar Terrestrial Relations Observatory
- **SECEF** Sun-Earth Connection Education Forum

Partnering with ELISA provided unique opportunities to further extend the reach of the program by targeting teachers of students in Latino/Hispanic populations. Coupled with workshops at SACNAS conferences, the ELISA-partnered workshops ensured that THEMIS-related science reached a broad population of underserved and minority students.

In this chapter, we consider a 'core group' of 17 workshops for which we have comprehensive and parallel data using a standardized questionnaire with 292 participants. Moreover, we have general data from the 13 'additional workshop venues' that have 258 participants who completed questionnaires tailor-made to each workshop. The short-term workshops are discussed in two sections…

- The core group
- Additional workshop venues

The Core Group

At the close of 2005, the evaluator collaborated with the E/PO team in developing a standardized questionnaire. It was designed to collect identical information from participating teachers across all short-term workshops. These data pertain to workshop effectiveness and improvement, as well as teachers' intended implementation and dissemination practices.

Clearly, the impetus for designing one, standardized questionnaire for short-term workshops was to enable evaluators to carry out a comprehensive, summative analysis of the data across all events. Prior to this point, the focus of data collection was formative and narrow and was carried out on a workshop-by-workshop basis. The standardization of the questionnaire allows a comprehensive look across multiple workshops in the context of the entire program.

THEMIS team engages workshop attendees.

The 'core group' of teachers included those who completed the standardized questionnaire after attending workshops between August 2006 and March 2009. The majority of these workshops, presenting topics related to the THEMIS mission, was offered in partnership with other NASA missions—FAST, STEREO-IMPACT and RHESSI. Additionally, the THEMIS team held collaborative workshops with the Sun-Earth Connection Education Forum at Berkeley and the ELISA project. Table 3 lists the venues where the 'core group' attended workshops and provides the number of participating teachers who completed questionnaires.

THEMIS—SHORT-TERM WORKSHOPS The Core Group		
Date	**Workshop Venues and Partners**	**# Respondents**
	State/National	
OCT 06	CSTA with FAST	13
OCT 06	CSTA with FAST and STEREO	24
MAR 07	NSTA with FAST and STEREO	14
OCT 07	CSTA with FAST	15
MAR 08	NSTA	11
NOV 08	CSTA with STEREO and RHESSI	26
MAR 09	NSTA with FAST	18
MAR 09	NSTA with RHESSI	17
	State/National Total	**138**
	Local	
DEC 06	SSL with FAST and STEREO	11
FEB 07	SSL with FAST and STEREO	21
JUN 07	SSL with FAST and STEREO	15
APR 08	SSL with FAST, STEREO, RHESSI and SECEF	10
AUG 08	SSL with ELISA	16
NOV 08	SSL with ELISA	11
	Local Total	**84**
	Special	
AUG 06	MI—Tribal College with FAST and STEREO	12
FEB 07	FL—Cape Canaveral THEMIS mission Launch	36
MAY 07	CA—Turtle Bay Exploration Park with FAST and STEREO	22
	Special Total	**70**
	Grand Total	**292**

TABLE 3. SHORT-TERM WORKSHOPS—The Core Group. Listing of dates, venues, partners and number of questionnaire respondents for a 'core group' of short-term THEMIS workshops held from 2006 through 2009.

The 292 teachers responding to the questionnaires at these workshops, which offered topics related to the THEMIS mission, provided the following information about themselves and the environments in which they teach…

Teacher experience	N=225	• Averaging 11.8 years of experience with range from 1 to 40 years
Grade levels taught	N=250	• 41% elementary • 27% middle • 29% high school • 3% post high school; NASA Ambassadors for related projects
School setting	N=243	• 53% suburban • 35% urban • 12% rural
Title I & free lunch program	N=177 N=183	• 40% teaching in Title I schools • 50% students receiving free/reduced lunches
Underserved students	N=194	• 68% of students are underserved populations in science education—47% girls and 21% non-White, non-Asian boys

Two-thirds of the teachers said that they learned about workshop opportunities from e-mails. Their interest was piqued by these electronic messages describing the THEMIS-related science that would be the topic of these sessions. The remaining third cited personal contacts, flyers and the Web site as the sources from which they learned about THEMIS workshops.

The specific subject matter offered in workshops was often cited as igniting teachers' desire to attend—48% cited areas of interest such as magnetism and auroras. Twenty-three percent was drawn to the workshops because of the topics' relevance to their teaching assignments or compatibility with state teaching standards. The remaining teachers mentioned general interest, the reputation of NASA and referrals as motivators for signing up.

"I am particularly interested in the Sun's magnetic field and how it affects the aurora borealis."—*Workshop Participant*

The seventeen workshops offered a total of 72 presentations related to the THEMIS mission. Teachers' knowledge about THEMIS-related science grew substantially from pre- to post-workshop. Teachers rated their post-workshop understanding of the topics covered as being 'clear'. This is evidenced by a mean rating for all participants for all sessions of 3.5 on a 4-point scale ranging from '1-not clear at all' to '4-very clear'. This is in stark contrast to their prior knowledge of the topics. They reported that before attending the workshops, their knowledge of the topics was between 'just a little' and 'moderate'—the translation of our finding of a 2.5 mean rating on a 4-point scale ranging from '1-almost no knowledge' to '4-quite a bit of knowledge'.

With regard to implementation of the THEMIS-related materials/ideas, teachers reported that they were 'very likely' to use them in their classrooms—offering a mean rating of 4.0 on a 5-point scale ranging from '1-will not present' to '5-certain to present'. Fifty-eight percent of the teachers anticipated that they would be using workshop information primarily as integral parts of basic science courses, while 48% envisioned using these materials as resources or supplements to the basic curriculum—a few teachers would be using materials in both ways. This is dramatically different from their use of these topics prior to the workshops. Before THEMIS, an average of 28% said that they had never taught the topics presented, 36% had used the topics as resources or supplements to basic science courses and only 30% had used THEMIS-related materials/ideas as integral parts of their courses.

"Time is a potential barrier—I worry about getting through the entire curriculum."—*Workshop Participant*

Despite the high percentage of teachers eager to implement THEMIS materials and ideas, some expressed concern that their ability to use the materials would be hampered by time constraints and a lack of financial support to purchase materials, scarce resources and a deficiency in classroom technology.

The findings from this core group of teachers suggest that the workshops have presented complex materials to teachers in a clear manner that gives them the confidence to present the materials to their students. Additionally, they are most likely to include the materials and ideas as integral parts of or resources to supplement their basic science courses.

Additional Venues

In addition to the nearly 300 teachers for whom standardized data were gathered, another 258 teachers attended short-term professional development workshops at state and local venues. This number includes participants at workshops from July 2003 through February 2005, colleagues attending a presentation at the Astronomical Society of the Pacific held in June 2008 and participants at existing workshops where an E/PO team member 'dropped in' to make a THEMIS-related presentation. These venues and number of participants are summarized in Table 4. Non-standardized questionnaires were used at a majority of these venues. At workshops where a THEMIS team member 'dropped in', no questionnaires were distributed.

THEMIS—SHORT-TERM WORKSHOPS
Additional Venues

Date	Workshop Venues and Partners	# Participants
JUL 03	SSL	20
FEB 04	SSL	24
APR 04	NSTA	38
JUL 04	SSL	15
AUG 04	SSL	18
OCT 04*	**TX—SACNAS National Conference**	**20**
NOV 04*	**AK—AISES National Conference**	**5**
FEB 05*	**SSL**	**27**
JUN 08	ASP with ELISA—Presentation to colleagues	18
Various	Four existing workshop add-ins (JAN 08 through FEB 09)	73
	Total	**258**

*Reports of findings from these workshops are available on the THEMIS Web site.

TABLE 4. SHORT-TERM WORKSHOPS—Additional Venues. Listing of dates, venues, partners and number of participants in short-term THEMIS workshops held at additional venues from 2003 through 2009.

As previously discussed, initial efforts (2003–early 2005) to collect participant data at short-term, THEMIS workshops were focused on obtaining formative feedback for improving these workshops. Building on their previous experiences in conducting workshops, the E/PO team used questionnaires tailor-made for each workshop venue and designed to inform improvement. Data collected from these workshops were selectively analyzed.

In fact, evaluation reports for three of these workshops (in bold, Table 4.) can be found at the THEMIS E/PO Web site under 'E/PO Evaluations'. These workshops are representative of the THEMIS program's early forays into conducting short-term workshops. Of particular note are the workshops held at the SACNAS and AISES National Conferences. Both of these venues reached out specifically to teachers whose students were predominantly underserved minorities in the sciences—e.g., Native Americans and Latinos. In fact, the AISES conference was held in Anchorage, AK drawing in teachers serving Native Alaskan students.

According to conservative estimates of the THEMIS E/PO team, each teacher attending a short-term workshop reaches an average of 88 students per year and shares THEMIS-related materials/ideas with four of their colleagues. Consequently, it was estimated that from these three minority-focused workshops alone, participants may have reached over 4,500 students and more than 200 colleagues once they returned to their classrooms.

Other highlights of these workshops enumerated below are also indicative of most early workshop efforts…

- Nearly two-thirds of the workshop participants were impressed with THEMIS-related materials/lessons and praised them for being 'ready to use' —*OCT 04 SACNAS National Conference*
- Nearly three-quarters of the participating educators reported that the presentation was 'better than most'—*OCT 04 SACNAS National Conference*
- Teachers overwhelmingly (80%) cited 'hands-on activities' as what they liked most about the workshop—*NOV 04 AISES National Conference*
- Teachers indicated that they were very likely to recommend to their colleagues all of the materials presented, citing 'Living with a Star' and 'Reasons for the Seasons' most often—*FEB 05 SSL*

These findings indicate that the early short-term workshops were clearly 'hitting the mark' in delivering to educational professionals ready-to-use, hands-on activities promoting the teaching of THEMIS-related science to their students. The E/PO team also learned that they were 'on the right track' in making presentations that were deemed 'better than most' and in inspiring educators to implement THEMIS materials/ideas in their classrooms and to share what they had learned with colleagues.

The 2008 meeting of the Astronomical Society of the Pacific (ASP) afforded an opportunity for THEMIS team members to partner with the ELISA project in making a presentation to 25 colleagues in the E/PO field. Entitled 'Effective Strategies for Engaging Latino/Hispanic Audiences in Astronomy during the International Year of Astronomy' this THEMIS/ELISA workshop brought together a broad spectrum of educational professionals including outreach specialists and program managers. These participants were seeking ways to engage their communities—in particular Hispanic areas—in the study of astronomy.

"I work at a community college planetarium with 60% Hispanic students; some schools are 90% Hispanic. The need is there to provide more, specifically to those folks."—*Workshop Participant*

The ASP workshop participants completed questionnaires specifically designed to elicit feedback about the unique nature of this workshop. They indicated that the populations they worked with were, on average, 28% Hispanic. According to these educators, the Hispanic component of the populations they served ranged from 0% and 93% and was typically located in urban settings. All respondents indicated that they intended to incorporate THEMIS-related materials/ideas into their own workshops and community events. They also envisioned more outreach to the Latino community and the expansion of the THEMIS program to include additional underserved audiences.

Taking advantage of every opportunity to 'spread the word' about the THEMIS mission and its related science, the E/PO team also offered to make presentations at already existing workshops. So from January 2008 through February 2009 an additional 73 educators benefited from workshops that were not primarily about THEMIS-related science, but included THEMIS sessions.

All workshops, both the 'core group' and those held at additional venues, directly reached at least 550 educators based on the number completing questionnaires. Indeed, the total number of workshop participants is likely to have been even greater due to the fact that some participants fail to fill out questionnaires because they leave early. Again using the THEMIS team's estimates of workshop participants reaching 88 students and 4 colleagues per year, we submit that in the first year after the workshops, these 550 participants exposed 48,400 students and 2,200 colleagues to THEMIS-related materials/ideas.

Key Factors for Success: Short-Term Workshops Address NASA's Goals

As mentioned in the first chapter, NASA considers four critical elements or goals when evaluating program proposals—their intrinsic merit, relevance to NASA objectives, cost and program balance factors (refer to page 25 for detail). This section discusses how the short-term workshops met NASA's goals and in so doing summarizes the impact of this component of the THEMIS program.

Workshops intrinsic merit—Offering short-term professional development workshops for K-12 teachers at national, state and local venues further extended the reach across the country of the **NASA's THEMIS mission and related science**. Teachers were drawn to workshop presentations that offered materials they could use and covered topics of interest to them, for example, auroras and magnetism. With many of the workshops conducted in partnership with other NASA missions such as STEREO and FAST, the **continuity** resulting from having connected teachers to other missions was assured.

The **partnerships** forged with five other NASA missions and programs—ELISA, FAST, RHESSI, STEREO and SECEF—ensured that new audiences with interests in these missions and programs were also introduced to THEMIS-related science. Workshop agendas developed in partnership can be easily replicated in multiple venues and continued far beyond the grant period of THEMIS or any of the other programs—thus, maximizing **sustainability**. Furthermore, workshop participants have clearly indicated their intention to continue implementing THEMIS-related materials/ideas and to share them with colleagues.

A comprehensive **evaluation** of workshop impact was facilitated by the development of a standardized questionnaire incorporating quantitative and open-ended queries for gathering data across all workshops. Findings indicated that short-term workshops succeeded in clearly presenting complex materials/ideas to teachers, thus, giving them confidence to implement THEMIS-related science as part of their basic science curriculums.

Workshops relevance to NASA objectives—Short-term workshops offered to educators NASA mission **content and related science.** The educational content is aligned to national and state standards with hands-on activities that can easily be implemented in K-12 classrooms. Teachers indicated that they especially appreciated these hands-on activities.

Partnering with ELISA afforded an opportunity not only to expand the reach of THEMIS-related science education, but also to meet **customer needs** for educators in the Hispanic community. Further efforts to address the needs of the Hispanic community included presenting workshops at SACNAS. Educators for the underserved Native American/Alaskan population were also sought out for inclusion as workshops were taken to the AISES National Conference.

Workshops cost—Effective use of funds was made possible not only through leveraging partnerships, but also by presenting many of the workshops at national and state venues where educators were already gathering for conferences.

Workshops program balance factors—The E/PO team made special efforts to reach minorities in STEM by taking short-term workshops not only to SACNAS and AISES, but also to a tribal college in Michigan. Additionally, findings indicate that about two-thirds of the 'core' group's students represented underserved minorities in science education—that is, girls and non-White, non-Asian boys. Consequently, the **diversity** of populations served by THEMIS' short-term workshop component is well-established.

Bringing THEMIS' hands-on activities to these targeted and diverse populations has opened the door for underserved, underrepresented students to learn about STEM. Student exposure to THEMIS-related materials/ideas will position them in the **pipeline** for pursuing STEM careers.

PART 4: PUBLIC OUTREACH—BEYOND THE CLASSROOM

'Spreading the word' about the THEMIS mission and its awe-inspiring science has entailed not only the E/PO team's formal education efforts, but also two public outreach components—the Web site and the ViewSpace museum show. Both of these informal education elements were designed to expand the reach of mission science beyond the classroom.

The Web site opens the 'window on the soul' of the mission's discoveries in a language accessible to the general audience as well as serving as a valuable resource/reference for teachers and students alike. The ViewSpace presentation—'Probing the Mysterious Aurora'—has captured the attention of planetarium and science center visitors around the world by drawing them into the story of THEMIS.

This chapter focuses on the impact made by these public outreach components. The following topics are discussed…

- THEMIS E/PO Web site
- ViewSpace show
- Key factors for success

PUBLIC OUTREACH FAST FACTS

☼ *The THEMIS E/PO Web site has had close to 900,000 successful requests for pages since its launch in 2003*

☼ *Visitors from 118 countries, including the USA, have viewed the web site since it was started in 2003*

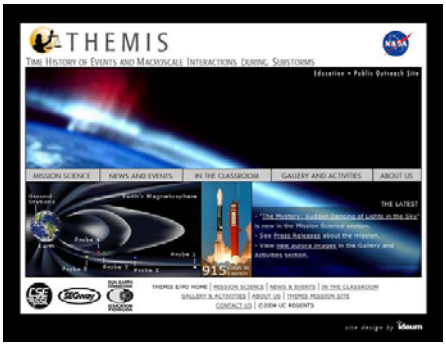
☼ *The ViewSpace museum show is currently in 200 museums and science centers around the world and is estimated to have been shown 5,500 times per month*

☼ *The network of museums in which ViewSpace is exhibited grows at a rate of 3 to 4 per month*

THEMIS E/PO Web Site

The THEMIS E/PO Web site, found at http://ds9.ssl.berkeley.edu/themis, was launched in December 2003 on the heels of the THEMIS mission's approval earlier that same year. From its inception, THEMIS E/PO Web site visitors have been greeted by a home page designed to easily direct them to their area of interest.

The Web site continues to fulfill its own mission of disseminating and sharing THEMIS-related science with teachers, students and the general public through its offerings which include…



Home Page of THEMIS E/PO Web site—featuring a map of a substorm and showing the five probes launched on February 17, 2007.

- **Mission Science**—Information and multimedia about the science and engineering of THEMIS
- **News and Events**—Updated news about the THEMIS mission in language 'easy to understand' by the public
- **In the Classroom**—GEONS data and GEONS teacher guides with classroom activities
- **Gallery and Activities**—Images, videos and games plus links to interactive sites related to the THEMIS mission
- **About Us**—Information about the THEMIS E/PO progra

As the spacecraft were being built and readied for launch, the E/PO team was already bringing mission science to the public via the Web site. The site was also playing a critical role in the GEONS project as the network was forming and making inquiry-based, THEMIS-related science activities available to teachers nationwide. Since its inception, the Web site has continued to serve as an important link and 'gathering place' for the GEONS network and shares its work with the general public as well as other educators.

Spanning the years from the Web site's inception in December 2003 through September 2009, the 'life of the Web site' can be viewed in three distinct periods…

- **Start-up**—Web site launch December 2003, infrastructure for GEONS network is being built and mission awareness is being raised
- **Build up and Mission Launch—**Anticipation building; culminating in the February 2007 mission launch
- **Sustaining—**Spacecraft sending data back to ground stations, posting data to site and updating

Figure 2, offers a brief look at the activity levels for visitors accessing the Web site for these three distinct periods. Activity levels will be discussed in greater detail in the next section, however, in the interim it is easy to see that interest in the Web site has continued to build and that the site has sustained that interest beyond the mission launch.

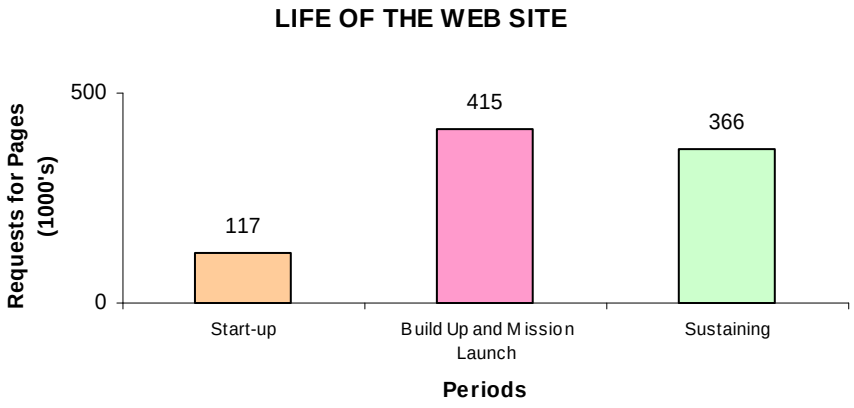


FIGURE 2. PUBLIC OUTREACH—Life of the Web Site. Depiction of activity levels on the THEMIS E/PO Web site during three distinct periods.

A note about the analysis periods…

Each of the three periods of the 'life of the Web site' consists of two fiscal years as shown below…

Period	Fiscal Years	Dates
Start-up	FY04-FY05	10/1/03-9/30/05
Build up and Mission Launch	FY06-FY07	101/05-9/30/07
Sustaining	FY08-FY09	10/1/07-9/30/09

Statistics from the Web site have been gathered since its December 2003 launch and continue to be gathered on a daily basis. For this report, statistics collected since the Web site launch through September 30, 2009 were analyzed. With NASA's fiscal year beginning October 1 and ending September 30, five full fiscal years—FY05 through FY09—are included. FY04 incorporates data for a partial year (Dec03 to Sept04), but has been adjusted to approximate a complete fiscal year.

The launch of the Web site occurred approximately two and a half months into FY04. Thus, actual data from that year account for about four-fifths (79%) of a complete fiscal year. We assume that statistics for the early days of the Web site would have been the same had the site been launched at the fiscal year's beginning. Thus, we have adjusted FY04's actual data to approximate a complete fiscal year. This adjustment aids our data analysis by making each of the periods in the 'life of the Web site' comparable.

Throughout the 'life of the Web site', data have been gathered about its visitors and how often the Web site was accessed. Findings from the analysis of these Web site statistics are discussed in the remainder of this section—with sub-sections describing activity levels and visitor profiles.

Activity Levels

Visitors to the Web site have enjoyed 'hit' rates ranging from 80% in the first two start-up years to 83% in the build-up and launch period to 86% in the most recent sustaining years. We define a 'hit' rate as the percentage of times a visitor successfully accesses specific Web pages without receiving error messages. This rate, representative of Web site traffic, has steadily improved over the life of the site.

The conventional way to define 'hit' rates misrepresents Web site traffic. Traditionally, rather than counting a Web page as a 'hit', some Web monitors count files on a Web page. A single Web page can be made up of any number of unique files (hundreds even). Thus, considering each file on a Web page as a 'hit' is less reflective of Web traffic and more indicative of Web page complexity. Consequently, for the remainder of this discussion we refer to the Web site's activity levels in terms of requests for a page—a page that has been viewed by a visitor rather than all of the files that make up that Web page.

Since its inception, the Web site has enjoyed close to 900,000 successful requests for pages. The site's activity level expanded three and a half times from the first period start-up (117,067) to the launch period (415,017). Activity levels in the sustaining period (365,579) have dropped a modest 12%, but remain at a level far above those in the site's early years. Figure 2 provided a visual representation of this activity pattern. Details of the data for average activity by month and by day are captured in Table 5.

THEMIS—PUBLIC OUTREACH
Activity Levels

Requests	PERIOD 1—Start-up FY04-FY05	PERIOD2—Build Up and Launch FY06-FY07	PERIOD 3—Sustaining FY08-FY09
Total # Successful Requests for Pages—'hits'	117,067	415,017	365,579
Average 'hits' per month	4,878	17,292	15,232
Average 'hits' per day	321	1,136	1,009

TABLE 5. PUBLIC OUTREACH—Activity Levels. Successful requests for pages—'hits'—for each of the three periods.

Activity levels often fluctuate and can spike dramatically with significant events. For example, March 2007—the month immediately following the THEMIS mission launch—proved to be the most active month over all six years of the Web site's existence. In that month alone, there were over 41,000 'hits'—successful requests for pages. In fact, from January through April of the mission launch year there were close to 128,000 'hits' or about 32,000 per month, on average. Other spikes in monthly activity have been observed when there has been…

- OCT 2005—A partial eclipse of the Sun
- MAR 2007—Sun-Earth Day Forum Web cast highlighting all NASA missions
- AUG 2009—A rebroadcast of the THEMIS mission story on *NOVA Science NOW* as well as the announcement of the extension of the THEMIS mission

We also noted that Wednesdays through Fridays are the days of the week on which the highest activity levels have been observed. We speculate that these patterns are reflective of students' online activity increasing toward the middle and end of the school week, once their teachers have covered the basic curriculum in the earlier part of the week. Once the basics have been covered, teachers are more likely to provide 'free' time for students to do their own research on curriculum-related topics like the THEMIS mission.

Visitor Profile

On a daily basis throughout the 6-year life of the Web site, domain names of visitors have been catalogued. This offers an avenue for identifying their countries of origin. Altogether, visitors have hailed from 118 countries including the United States of America. Not surprisingly, the majority of visitors came from domestic USA-based domains. Table 6 presents a summary of the locations from which visitors' inquiries originated for each period.

In the most recent, two-year period, the domain names for 78% of the visitors are from the United States, while 6% are from other countries with the largest number of foreign visitors coming from the Czech Republic, Japan and Canada. An additional 16% were from addresses that could not be identified.

THEMIS—PUBLIC OUTREACH
Web Site Visitor Profile

Requests by Origin of Domain	PERIOD 1—Start-up FY04-FY05	PERIOD2—Build Up and Launch FY06-FY07	PERIOD 3—Sustaining FY08-FY09
Numerical addresses not identified	40%	49%	16%
United States	55%	49%	78%
Other countries	5%	2%	6%
Total	100%	100%	100%
Number of Other Countries	81	72	111
Top Three Other Countries	Canada Japan Germany	Canada Switzerland United Kingdom	Czech Republic Japan Canada

TABLE 6. PUBLIC OUTREACH—Web Site Visitor Profile. Percentages of locations from which visitors access the Web site for each of the three periods.

At first blush, it appears that the percentage of domestic visitors has increased from a low of 49% of the site's visitors in the second period to 78% in the third period. However, it is also the case that the addresses that could not be identified dropped from 49% to 16% of the visitors. It is likely that the increase in United States visitors results from improvement in the identification of these domestic domains.

While the origin of almost one-fifth of the domain names continues to remain a mystery, it is gratifying to know that visitors from 118 countries around the world are accessing the Web site. Canada's place among the top three has no doubt been secured as a result of the THEMIS science mission's ground-based observatories (GBOs) of which some 16 are located in Canada. Moreover, some of the E/PO team's informal efforts have been in partnership with Canadian-based groups.

Through these partnerships, magnetometer and radio wave data related to space weather have been brought into the classroom setting in Canada as well as the United States. Additionally, Canada has a special interest in predicting space weather for its relevance to the aurora tourist industry. The Canadian tourist industry is highly in-tune to any information/data that can aid them in pinpointing the best times for viewing auroras so that their visitors can have an awe-inspiring experience.

The ViewSpace Show

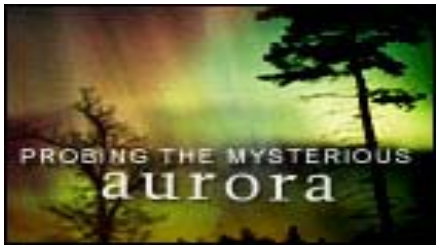
In partnership with the Science Telescope Science Institute (STScI), the E/PO team found a way to introduce the THEMIS mission and its related science to a wide-ranging audience of museum visitors throughout the world. They used ViewSpace to present a visually captivating show entitled 'Probing the Mysterious Aurora.'

Example of a ViewSpace exhibit.

ViewSpace is a permanent exhibit for museums and science centers that uses a multimedia PC and large-format displays such as plasma screens to show free-running multimedia presentations. ViewSpace combines beautiful high resolution images, digital movies/animations, interpretive captions and evocative music. In fact, ViewSpace received a 2003 MUSE Award from the American Association of Museums in recognition of its excellence as a media program for museums.

Content is uploaded to the exhibit's PC and is updated daily. Visitors to the planetariums, science centers or museums are free to take in ViewSpace for a few minutes at a time or an hour or more as the 'loop' of shows is presented.

The 'Probing the Mysterious Aurora' show displays beautiful auroral imagery, all-sky movies, THEMIS animations and interpretative text woven together to tell the THEMIS story. As part of ViewSpace exhibits, the THEMIS-themed production has been placed throughout the world in more than 200 museums and science centers. It is estimated that the THEMIS show has been presented more than 5,500 times per month. With venues in the network increasing at a rate of three or four per month, viewing opportunities continue to grow. Furthermore, there is another ViewSpace news service that features the latest results from a variety of solar observatories and probes, including THEMIS. This service has been performed more than 14,000 times per month.



A frame from the THEMIS ViewSpace display.

"I have observed people sitting in front of the ViewSpace exhibit for long periods of time, engaged in watching the program…commenting on the high quality of the production and marveling at the beauty of the images"*—Bishop Museum Planetarium, Honolulu, Hawaii*

The free-running nature of the ViewSpace presentation makes it difficult to obtain meaningful statistics specific to the viewers of 'Probing the Mysterious Aurora'. The total number of visitors who have viewed the THEMIS show depends on a variety of factors—the quality of the installation, the quality and quantity of the 'competition' within the same venue, the degree to which a lengthy experience fits the desire of the visitor and the number of other ViewSpace shows being shown in the 'loop'.

However, we do have some sense of the potential reach for a ViewSpace show. According to annual visitor attendance records posted on http://hubblesite.org/explore_astronomy/visit_viewspace/ for a number of ViewSpace venues in the United States, the number of visitors to planetariums, science centers and museums can range from 3,000 to 2,000,000.

STScI proved to be a generous partner. Not only did they share ViewSpace venues with the THEMIS program, but contributed its services at no cost. With a worldwide network and the infrastructure in place to present awe-inspiring visual images from a NASA mission, a partnership with STScI proved to be an effective way of reaching a large audience through an E/PO program.

Key Factors for Success: Public Outreach Addresses NASA's Goals

As mentioned in the first chapter, NASA considers four critical elements or goals when evaluating program proposals—their intrinsic merit, relevance to NASA objectives, cost and program balance factors (refer to page 25 for detail). This section discusses how the public outreach components—E/PO Web site and ViewSpace show—met NASA's goals. In doing so, it summarizes the impact of these components of the THEMIS program.

Public outreach intrinsic merit—Bringing **NASA science** to the public through the wonder and awe of auroras is one of the goals of the THEMIS public outreach effort. The THEMIS E/PO Web site succeeds in introducing NASA science to the desktops of the curious in language that is accessible to them. ViewSpace offers museum visitors the beautiful, awe-inspiring imagery of auroras in telling its story of the **THEMIS mission**.

Today the public outreach components continue. Each day, as 'Probing the Mysterious Aurora' remains in the loop of visual displays for ViewSpace, museum visitors somewhere around the world are being captured by the mystery of auroras. **Evaluation** statistics indicate that the Web site continues to attract visitors even today—well beyond the initial excitement of the mission's 2007 launch. Both of these critical components have demonstrated their **sustainability** up to the present and are well-positioned for educating the public into the future.

Partnerships forged with other NASA entities have contributed to the success of both the ViewSpace show and the Web site. The STScI's generous support and guidance have provided the THEMIS program with an ever-expanding array of venues for ViewSpace. Web site links to other NASA sites including Goddard Space Flight Center, SEGway and the Sun-Earth Connection Education Forum offer avenues not only to promote NASA science efforts, but also to direct interested visitors to the THEMIS mission itself.

Public outreach relevance to NASA objectives—NASA's THEMIS mission **content** is the centerpiece of the E/PO Web site. This site is accessible to the general public as well as to educators and their students who seek to learn more about mission-related science. The Web site **meets the needs** of these visitors by engaging them interactively—capturing and retaining their interest.

In addition, venues designed to entice the general public such as museums, science centers and planetariums offer visitors ViewSpace shows, like 'Probing the Mysterious Aurora'. The show meets the content needs of museums seeking the latest in space mission science and discoveries. Simultaneously, it also meets the needs of museum goes by providing a visual impact experience that is 'almost like being there'.

Public outreach cost—Delivering THEMIS-related science to an audience around the world with the speed and reach of the Internet proves to be a cost-effective means of 'getting out the word'. Reaching out to museum, science center and planetarium visitors, via the ViewSpace venue offers opportunity for worldwide exposure at a very low cost to the THEMIS program.

Public outreach balance factors—Establishing a **pipeline** or addressing **diversity** through targeting specific groups, were not the primary aims of public outreach. Consequently, no measurements of impact in these areas were taken. However, through their very nature, both components have attracted a diverse audience worldwide. We know that visitors from 118 countries have sought out the THEMIS E/PO Web site. We also know that special efforts of educators bring diverse populations—especially children—to museums, science centers and planetariums.

PART 5: INFINITY AND BEYOND—THE FUTURE OF THEMIS

The THEMIS E/PO program has built a solid foundation for disseminating THEMIS-related science and sustaining its efforts. A look into the future—'to infinity and beyond'—reveals that after the initial funding period, there are indeed vibrant 'signs of life' that ensure the program's continuation. First, this section provides evidence for the program's solid foundation by discussing NASA's early recognition of the quality of the THEMIS E/PO effort as well as providing compelling evidence of how the program's goals were met. Once this strong base is established, we share projections about the program's future as embodied in the Heliophysics Educator Ambassador Program (HEA) and other THEMIS-related activities that flow out of the original program.

White Paper Review and 'Lessons Learned'

In 2004, a 'white paper' review of NASA Education Programs was completed. Its purpose was to gain a more in-depth understanding of a select subset of programs, previously reviewed as part of the 2003 Program Reviews, by testing them with a revised set of review procedures. The THEMIS program was one of few that were selected for this in-depth review. A 'Very Good' rating was awarded to the THEMIS program for all criteria—customer focus, partnerships/leverage/sustainability, evaluation, content, pipeline and diversity. The program was deemed to be well-defined, well managed and successful. The following program strengths were mentioned…

- Program is accessible to intended audience and based on mutual need—educators' need for 'compelling' teaching tools and NASA's need for well-educated future scientists
- Creative partnerships that have been established add to the strength of the program
- THEMIS heeds 'lessons learned' from previous missions, so the program is not wasting time 'reinventing the wheel'
- Program promotes the improvement of STEM skills for participating students and will likely inspire interest in STEM careers
- Program makes a special effort to include Native American and Hispanic students

The E/PO team was assured it was 'on the right track' in meeting NASA criteria—a valuable affirmation to have so early in the program. Throughout THEMIS' grant period, there has been ample opportunity for program self-reflection as valuable feedback came in from periodic evaluation summaries and debriefings as well as from Web site statistics.

The E/PO team can point to 'lessons learned' that revealed themselves through these evaluative activities, observations and self-reflections. Captured in a 2008 research article published in *Space Science Reviews* (referenced on page 2) the lessons are summarized as…

- Provide teachers with training on specialized equipment, with lessons using 'real' data and with regular support—Having experienced the failure of programs without these elements, teachers confirm that these factors are critically important for 'buy-in' and implementation
- Simplify and modify teacher guides to ensure usage—Given teachers' struggle to fit all curriculum requirements within the school year, any additional materials must be easy to use in order to maximize adoption

- Get a partner responsible for finding teachers and filling in gaps when necessary—Recruiting teachers to fill the gaps left by those leaving the project proved to be more time-consuming and difficult than expected despite having good, solid relationship with school administrators
- Secure funding for teachers/students to work with complex data—Teachers were more likely to work with complex data and have their students do so when they were funded for their 'extra effort'
- Secure technical support—Technical expertise from the ground-based observatory hardware and software team was crucial in ensuring proper installation and maintenance of the magnetometer sites
- Train mission scientists for contact with public/teachers—Build in support for and education of mission scientists in effectively interacting with the public or with teachers

Meeting Program Goals

There are two compelling and comprehensive ways to demonstrate the effectiveness of a NASA-funded program such as THEMIS—to weigh its outcomes against NASA's measuring scale and also against the programs' original goals. Since NASA-funded programs are crafted based on NASA's factors/elements, these two pictures of success can look somewhat similar. Nonetheless, each strategy for looking at program efficacy has its merits. At the conclusion of each chapter, we have already looked at the components of the THEMIS program through the lens of NASA's factors. This section reveals how the evaluative outcomes have successfully addressed THEMIS' initial goals established in 2003.

The current Lead E/PO scientist for the THEMIS mission, Dr. Laura Peticolas, has acknowledged Dr. Nahide Craig, who was the lead from 2003 until her 2007 retirement and has noted that "Dr. Craig made many of these outcomes possible." Dr. Peticolas has also offered praise to 'the many teachers who have been part of the THEMIS program, especially the eight 'core' teachers with magnetometers" as well as to the GEMS Lead at the Carson City, NV site. All of these dedicated educators can share in the success of achieving the THEMIS goals enumerated as follows…

GOAL I—Share the excitement of real-time measurements [magnetometer] with science teachers and their students.

Engaging teachers and students

- THEMIS' Geomagnetic Event Observation Network by Students (GEONS) project placed magnetometer sites in 13 rural, underserved schools/communities with real-time and archived data on-line for teacher and student use—exceeding original plan for 10 sites.
- Teachers using magnetometer data with their students provided evidence of the project's positive impact on students' attitudes toward science, their increased enrollment in science and their choice of science as a career.

Extending reach

- *The NewsHour with Jim Lehrer* featured three students deeply influenced by the THEMIS education program at the Petersburg, Alaska magnetometer site—potentially reaching more than five million viewers in two airings according to Nielsen ratings.
- *The PBS NewsHour* piece was picked up by National Public Radio and made available on the *Online NewsHour* Web site where it was linked to *NOVA Science NOW*'s Web site.

Establishing continuity

- The most actively engaged GEONS teachers have become involved in other NASA-related programs—Heliophysics Educator Ambassadors, GSFC's Cosmic Times, SOPHIA, RBSE, etc.

GOAL II—Develop physical science and Earth and space science lesson plans for nationwide classroom use—adhering to National Science Education Standards (NSES) at appropriate grade levels, incorporating THEMIS data and providing background content on the mission and magnetometers.

- The THEMIS team developed four teacher guides that included background information on the THEMIS mission and THEMIS-related science, classroom activities and student worksheets. GEONS teachers' feedback and NASA reviews enhanced the final product.
- THEMIS-related materials/ideas were extensively used over a period of five years by a core group of eight GEONS teachers who disseminated these materials to 275 of their colleagues and 2,720 students of whom approximately 75% were minorities in science.

GOAL III—Share THEMIS science in the context of other NASA missions such as FAST, STEREO and RHESSI.

- The THEMIS team partnered with other NASA-sponsored missions and programs—ELISA, FAST, RHESSI, STEREO and SECEF—in conducting short-term professional development workshops presented nationwide to K-12 teachers, primarily at national conferences.

GOAL IV—Provide teachers nationwide with professional development opportunities to learn more about auroras and solar storms and to take appropriate lessons back to their classrooms.

GEONS Teachers

- From 2004-2009, the THEMIS team provided intensive professional development for 20 high and middle school teachers associated with the magnetometers (GEONS teachers). A critical core of eight of these teachers disseminated THEMIS-related materials to 275 of their colleagues and 2,720 students.

GEMS Teachers

- The THEMIS grant funded a GEMS site launch in Carson City, NV that provided a two-day, extensive workshop experience to 42 elementary and middle school teachers. This site launch marked the beginning of what continues today as a permanent, independently operating site for the professional development of teachers, primarily from NV. During the first three years after is inception, the site has trained some 180 teachers.
- Over 150 teachers are on the LISTSERV and Google group associated with the GEMS site and continue to receive on a regular basis updates and information about additional professional development opportunities.
- The original workshop participants reported having the potential to share GEMS materials/ideas with 1,500 colleagues and expose 3,500 preK-8 students to GEMS materials/ideas. Three of the most actively involved GEMS teachers alone have shared GEMS materials/ideas with 150 of their colleagues.

Short-term professional development

- The THEMIS team has trained 550 K-12 teachers in 30 short-term workshops with those teachers reaching an estimated 48,400 students and sharing THEMIS-related materials/ideas with upwards of 2,200 colleagues.

GOAL V—Use existing infrastructure in order to avoid duplication of effort.

Using partners provides a cost-effective access to existing audiences

- The THEMIS team partnered with the Berkeley-based Lawrence Hall of Science (LHS) to add a GEMS network site in Nevada—also an ideal location for a magnetometer. This site benefits K-8 science teachers who instruct underserved students.

- The team partnered with other NASA-related projects such as ELISA to present workshops at the established AISES and SACNAS conference venues. These opportunities allowed THEMIS to extend its reach to teachers of Latino/Hispanic students.
- THEMIS-themed workshops were presented at numerous national and state venues where educators were already gathering for conferences. This leveraging of 'ready-made' audiences resulted in an effective use of funds.
- Partnerships were formed with science centers and K-14 educators allowing the THEMIS team to take advantage of existing venues in which the mission science could be offered in both free-choice learning and formal educational settings.
- Expanding THEMIS' reach in Canada has been made possible through partnerships with Canadian-based groups who have worked with an existing network of ground-based observatories.

Using partners allows for cost-effective dissemination

- The team distributed THEMIS materials in partnership with NASA's Sun-Earth Day and other established NASA-related training venues. This strategy has kept down costs associated with nationwide dissemination. As a result, over 20,000 CD-ROMs with THEMIS classroom books and 25,000 THEMIS flyers have been sent to teachers around the country.
- Partnering with a Public Relations group at NASA's Goddard Space Flight Center saved the THEMIS E/PO team development costs in finding ways to 'get the message out' about the Web site.
- The THEMIS contribution to the ViewSpace museum show was made possible through a partnership with the Science Telescope Science Institute that paved the way for a low-cost entry into ViewSpace's worldwide venues. ViewSpace is an established, award-winning distribution network for science information.
- The already established 'Night Sky Network' run by the Astronomical Society of the Pacific provided a cost-effective partnership in creating and printing postcards and lithographs for distribution to amateur astronomers.

GOAL VI—Partner with Tribal Colleges, schools on tribal lands and the Society for Advancement of Chicanos and Native Americans in Science (SACNAS) to reach minority and underserved groups.

Tribal lands and SACNAS help extend program reach

- Two-fifths of the 13 magnetometers were placed on tribal lands.
- Special effort was made to reach teachers with Native American and Latino students by presenting workshops at such venues as AISES and SACNAS.
- One of the short-term workshops held in 2006 was conducted at a tribal college in Michigan in partnership with FAST and STEREO.
- The GEMS site brought professional development opportunities to Nevada's underserved school districts including those on tribal lands.

Further evidence of reach to minorities and underserved groups

- The core group of GEONS teachers reported that 75% of their students are minorities in science—including girls and boys who are non-Asian or non-White.
- GEMS teachers were predominantly from underserved, underrepresented districts with almost half being rural locales. Additionally, one-third of their students represented minorities, including Native Americans.
- A core group of teachers attending short-term workshops reported that 68% of their students were underserved minorities in science education.

GOAL VII—Motivate scientists' involvement in E/PO.

Mission scientists become involved in both formal and informal education efforts

- Space scientists lent their expertise by providing training in the use of 'real time' data within the GEONS network as well as by offering their ideas for incorporating mission science into classroom lessons.
- Mission scientists served as presenters at teacher professional development workshops and mingled with teachers at the workshop's informal settings.
- The E/PO team supported classroom visits by mission scientists and engineers.

Mission scientists interact with students and teachers

- Students in the GEONS network collected data to assist mission scientists thereby exemplifying another opportunity for engaging scientists in E/PO activities.
- Mission scientists were available by phone and e-mail to GEONS network students, who received extra credit for contacting and interacting with THEMIS and other NASA mission scientists.
- GEONS teachers were afforded opportunities to work alongside THEMIS scientists in Boulder, Colorado.

GOAL VIII—Share THEMIS discoveries with teachers, students and the general public through well-developed E/PO Web pages.

- The THEMIS E/PO Web site has had close to 900,000 successful requests for pages since its launch in 2003.
- Visitors from 118 countries, including the USA, have viewed the Web site since its launch.

GOAL IX—Share with the museum-going public nationwide the awe of auroral substorms and the mystery of the trigger of these substorms' dynamic displays.

- The ViewSpace museum show is currently in 200 museums and science centers around the world and is estimated to have been shown 5,500 times per month.
- The network of museums in which ViewSpace is exhibited grows at a rate of 3 to 4 per month.

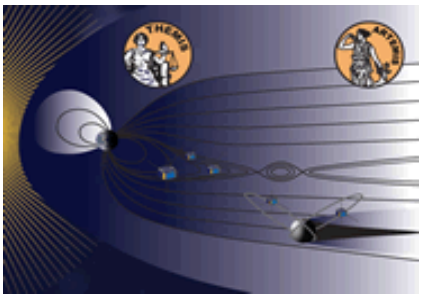
Following NASA specifications, the THEMIS team built a strong foundational E/PO program that is well-positioned for continued dissemination and long-term sustainability. Moreover, program outcomes reveal that the program's specific goals have been met—offering further evidence of the strength of THEMIS' E/PO efforts. With such a firm base, the future holds the potential for much more THEMIS-related science, presenting unique opportunities for continuing the work started in 2003.

Heliophysics Educator Ambassador Program

May 2008 proved to be a banner month for the THEMIS mission. On May 8th, NASA's Administrator bestowed the Group Achievement Award on the mission science team for the successful delivery, launch and operations of the THEMIS probes. The team was praised for its "tenacity and ingenuity." In addition, on May 13th, the THEMIS team received a Goddard Space Flight Center Group Achievement Award.

In the same month, the THEMIS team was further 'rewarded' with an extension of the THEMIS mission into 2012. The extended mission received final approval in July 2009. Having achieved most of its primary objectives of establishing when and where substorms begin, the extended THEMIS mission takes the two outer THEMIS probes into lunar orbits to perform solar wind, magnetotail and lunar science. These two probes have been renamed ARTEMIS.

In the Science Mission Directorate's May 2008 Senior Review Report the review panel congratulated the THEMIS science team "on their innovative plan to drastically reposition the five THEMIS probes at the conclusion of the prime THEMIS mission. The extended mission…is highly compelling, both for the individual scientific goals and what will undoubtedly be their excellent contribution to the Heliophysics Great Observatory." The extended mission offers an opportunity to take advantage of the established magnetometer network and trained educators. As a result, the THEMIS E/PO efforts have morphed into a new initiative—the Heliophysics Educator Ambassador (HEA) program—which has a broader Heliophysics theme.



Pictorial representation of ARTEMIS probes around the moon, as they will orbit in early 2011.

The focus of the GEONS project was to train teachers to implement THEMIS-related science lessons in the classroom. HEA's focus, however, will be on developing the capacity for an anticipated 70 educators to train other teachers on NASA Heliophysics science and educational resources. The program was kicked-off with a week-long teacher professional development workshop in Anchorage, AK in late June 2009. Presentations with Heliophysics themes were made by team members from seven NASA satellite missions, including THEMIS. The seven missions collaborating in this program along with their brief mission objectives are…

Mission Names		Mission Objectives
AIM	Aeronomy of Ice in the Mesosphere	Exploring polar mesospheric clouds (PMCs)
Cluster		Four satellites investigating Earth's magnetic environment and interaction with solar wind
IBEX	Interstellar Boundary Explorer	Studying the entire edge of the Solar System
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager	Exploring basic physics of particle acceleration and explosive energy release in solar flares
THEMIS	Time History of Events and Macroscale Interactions during Substorms	Understanding Space Weather
TIMED	Thermosphere Ionosphere Mesosphere Energetics and Dynamics	Studying influences of the Sun and humans on the Mesosphere and Ionosphere
MMS	Magnetosphere Multiscale	Solving Magnetospheric acceleration, Reconnection, and Turbulence (SMART)

Six GEONS teachers are now participating in the HEA program. It is noteworthy that all six of them were presenters at the HEA Workshop in Alaska workshop, taking part in either panel discussions or modeling activities for their peers. No doubt, it was gratifying for the THEMIS E/PO team to know that these GEONS teachers—the only teachers associated with any of the satellite programs to make presentations—were so confident in their abilities to convey their experience in teaching THEMIS-related science. They are clearly well on their way to fulfilling their role in training other teachers in the complete array of Heliophysics topics they are learning in this program.

Other THEMIS-related Activities

Coordination with partners—such as the Sun-Earth Connection Education Forum (SECEF), Science Education Gateway (SEGway) and networks supported by NASA Education—affords THEMIS E/PO an opportunity to disseminate resources nationally and to prevent duplication of effort.

Such partnerships have also played into the development of projects that were not part of the program's original vision. These efforts have the potential to spread THEMIS-related science beyond the program like tentacles reaching out and capturing the interest of new audiences never before touched.

Three of the projects arising out of these or other partnership contacts have already been completed. They are…

- THEMIS Flyers and CD-ROMS—Distributed 25,000 THEMIS flyers and 20,000 CD-ROMS with THEMIS classroom books to teachers around the country through NASA'S Sun-Earth Day program and teacher trainings
- Postcards and lithographs—Created and printed new materials to distribute through networks of amateur astronomers such as 'Night Sky Network' run by the Astronomical Society of the Pacific (ASP)
- Space Weather Multimedia Viewer—Supported update of SECEF's Space Weather Multimedia Viewer
- SpaceMath@NASA—Collaborated to develop more math problems featuring THEMIS for grades 3-12 found at http://spacemath.gsfc.nasa.gov/

Five additional projects are ongoing. They are…

- Broadening impact of GEONS—Offering opportunities for broadening dissemination of THEMIS-related science in HEA program. Widening the magnetometer network is also being considered.
- Sonification—Mapping data to sounds
- Teacher guides—Printing the finalized THEMIS teacher guides
- ViewSpace—Adding new THEMIS science updates to ViewSpace's THEMIS show
- Web site—Updating the THEMIS Web site with new science results and educational materials

The extension of THEMIS offers the prospect of even more discoveries to be shared with educators and the public. The E/PO team has established these and other effective pathways for this new knowledge to reach its intended audience as the future unfolds.