

THEMIS EDUCATION AND PUBLIC OUTREACH

**GEONS Teachers Interviews—Winter 2006
Executive Summary**

SUBMITTED SEPTEMBER 2006

Cornerstone Evaluation Associates LLC would like to express appreciation to its associate Ms. Marilyn Spisak for her work throughout this evaluation.

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Background

The THEMIS (Time History of Events and Macroscale Interactions during Substorms) Mission will determine the onset time and location of magnetic substorms of Earth's space environment, a prerequisite to understanding space weather. The nature of THEMIS science holds the potential for inquiry-based instruction at the high school level—in particular, instruction based on the correlation of ground-based measurements of auroral activity with spacecraft-based measurements of changes in the magnetosphere.

The Education and Public Outreach (E/PO) effort associated with the THEMIS Mission encompasses four distinct components...

- GEONS
- Conference-related workshops for science teachers
- Launch of GEMS site/Carson City, NV
- THEMIS Web site development

The centerpiece of the E/PO effort is GEONS, Geomagnetic Event Observation Network by Students—a network of 13 teachers and their students (as well as students participating on the web) who are using ground-based magnetometers for measuring auroral activity.

The THEMIS E/PO team has established 12 ground-based magnetometer stations each located in the proximity of a rural school in a traditionally under-served, under-represented community. A teacher at each of these locations (one school has two participating teachers) is responsible for the magnetometer data and system as well as for using the data with students through lessons/activities developed for this purpose.

A critical part of the E/PO team's work is the professional development of the GEONS teachers—providing both formal and informal guidance in using THEMIS-related guides/materials for classroom instruction. Since the GEONS teachers have magnetometers at their schools, they are in a unique position to implement THEMIS-related curriculum guides in their classrooms as well as disseminate the teaching materials among their colleagues.

The E/PO team provides formal training to GEONS teachers at annual summer workshops. During these workshops the E/PO team introduces the teachers to an inquiry-based approach to THEMIS science. The E/PO team provides GEONS teachers with THEMIS-related curriculum guides, materials and activities as well as instructs them in using this rich arsenal of materials with their students.

GEONS teachers receive informal guidance and materials via e-mail and a Yahoo! Group on an on-going basis. Additionally, the E/PO team encourages GEONS teachers to call them with questions and concerns and holds periodic teleconferences to promote sharing of ideas among teachers.

With the 2006 completion of magnetometer installations at all 12 sites and the formal presentation of THEMIS-related materials at summer workshops in 2004 and 2005, most of the GEONS teachers (save several newcomers) have by now had the opportunity to use these materials for classroom instruction and to share them with their fellow teachers.

Thus, the thrust of the 2006 telephone interviews with GEONS teachers—as well as the topic of this report—was to gain feedback on their experiences in implementing and disseminating the THEMIS-related materials. The information gathered in this process provided critical guidance to the E/PO team in revising THEMIS-related materials.

Evaluation Activities

The E/PO team engaged the services of Cornerstone Evaluation Associates LLC to conduct evaluation activities to provide both process and impact information for each of the E/PO components. Process information or formative evaluation involves documenting the strengths and weaknesses of each program component. These data are then fed back to the E/PO team so that they can make necessary improvements to the THEMIS-related workshops, web site and curricular materials.

Impact data or summative evaluation provides evidence of program effectiveness. These data indicate or measure the extent to which the E/PO team has been successful in achieving its goals.

A variety of methods are being used to gather both process and impact data on the GEONS component of the E/PO effort. These include questionnaires administered to the GEONS teachers at the 2004 and 2005 Summer workshops as well as telephone interviews conducted with the GEONS teachers in the Winters of 2005 and 2006.

The thrust of this report is to present the findings from the 2006 teacher interviews. Three previous reports covering the 2005 teacher interviews and the Summer workshops are available from Drs. Nahide Craig and Laura Peticolas at the Space Science Laboratory at Berkeley.

This report focuses on GEONS teachers' perceptions of their use and dissemination of THEMIS-related materials. The information they shared was used by the E/PO team to revise curricular materials, activities and guides.

Teachers interviewed were asked specifically about school and personal demographics, the use and dissemination of THEMIS-related materials and the challenges they may have encountered in using these materials, with an emphasis on a pivotal guide, *Exploring Magnetism on Earth*. What they shared, as well as the E/PO team's revisions to *Exploring Magnetism on Earth*, is summarized in the following sections...

- Demographics
- GEONS teachers' use and dissemination of THEMIS-related materials
- A close-up look at *Exploring Magnetism on Earth*—Challenges and revisions
- The future

Demographics

This section summarizes the demographics provided by the teachers including information about the schools in which they teach and the environments in which the schools are located. In addition, it provides more personal information about the teachers' training backgrounds and teaching experiences.

While 12 GEONS teachers were invited to participate in the 2006 telephone interviews, only eight—representing magnetometer sites in Alaska, Michigan, Montana, North Dakota, Nevada, Oregon, South Dakota, and Wisconsin—accepted this invitation. The four non-participants were from the site in Nevada, a second site in Alaska and sites in Pennsylvania and Vermont. A 13th teacher, from a second Michigan site, is now part of the GEONS team—having joined them after the Winter 2006 interviews. Interviews ranged in length from 20 to 57 minutes with an average interview lasting about 40 minutes.

The eight GEONS teachers interviewed provided details regarding the characteristics of the schools, districts and environments in which they are located as presented in Table 1. In summary, the teaching settings are described as follows...

- **A majority of rural schools represented**—Seven of the eight teachers interviewed teach in rural schools, with the exceptional teacher in a Nevada suburb.
- **A majority of middle and high schools represented**—Five of the interviewees teach in schools that are exclusively middle and high schools, while the remaining three teach in K-12 schools.
- **Relatively small student and faculty populations in schools**—On average, these schools are small with average student populations close to 550 and faculties numbering just over 35.
- **Relatively small student populations in districts**—For the five teachers who estimated the number of students in their districts, the average student population was around 2,700—ranging from 60 to 10,000.
- **Relatively small numbers of schools in districts**—For the seven teachers who estimated the number of schools in their districts, the number of schools per district ranged from 1 to 11 with an average of just under four per district.

SCHOOL DEMOGRAPHICS			
TEACHERS' STATES	SCHOOL ENVIRONMENT	SIZE OF SCHOOL	SIZE OF DISTRICT
		# Students/Faculty	# Schools/Students
AK	Rural - K-12	650/37	1 school/650
MI	Rural - 9-12	820/45	1H; 1M; 4E/2,500
MT	Rural - K-12	225/16	1 school/225
ND	Rural - 9-12	250/36	---
NV	Suburban - 7&8	1,400/70	1H, 2M, 8E/10,000
OR	Rural - K-12	60/6	1 school/60
SD	Rural - 9-12	250+/25	1H; 2E/M
WI	Rural - 9-12	700/60	1H; 1M; 2E

TABLE 1. 2006 GEONS INTERVIEWS—School Demographics. Presenting teachers' states, descriptions of their school environments, the number of students and teaching faculty in their schools and the number of schools and students in their districts.

When focusing on providing their personal information, like their educational backgrounds, teaching experiences and current teaching circumstances, the GEONS teachers shared a profile that, in summary, emerges as follows...

- **Undergraduate degrees in science and math prevail**—All GEONS teachers have undergraduate degrees in the sciences or mathematics.
- **Advanced degrees concentrated in science**—Five GEONS teachers have science degrees beyond their bachelors, including masters or doctoral degrees in the sciences.
- **15 years of teaching experience**—The average GEONS teacher has a little over 15 years of teaching experience, ranging from 4 to 31 years of teaching.
- **Entire teaching career devoted to science**—All GEONS teachers have been teaching science for their entire careers.
- **All teach at middle/high school level**—Currently all GEONS teachers are teaching at the middle and high school levels.
- **Teaching wide-range of science subjects**—GEONS teachers are teaching a wide range of science courses spanning from the basics—earth/physical science, biology, physics, chemistry—to the more unusual such as meteorology, anatomy, physiology and ecology.

GEONS Teachers' Use and Dissemination of THEMIS-Related Materials

This section presents general information on GEONS teachers' use and dissemination of THEMIS-related materials. It reveals which materials they are using, how they integrate these materials into their courses and at what grade levels and how they go about sharing these materials both formally and informally with their colleagues.

The E/PO team was most interested in how the GEONS teachers were using three specific guides that had been the centerpiece of the Summer workshops—*Exploring Magnetism on Earth*, the *THEMIS—GEONS User Guide* and *Exploring Magnetism (Grades 6-9)*. Additionally, they wanted to understand GEONS teachers' use of PowerPoint presentations and the Problem of the Week that had also been highlighted at the workshops. Thus, the interview protocol asked directly about these guides and materials. In the course of the interviews, GEONS teachers' spontaneously mentioned other THEMIS-related materials they had received and were using. Teachers were also queried about how they shared THEMIS-related materials with others.

The general findings relating to teachers' use and dissemination of THEMIS-related materials are presented in the following sub-sections....

- Which materials are being used
- How materials are being used
- How materials are disseminated

While this section covers general use and dissemination of THEMIS-related materials, the next main section presents a detailed examination of teachers' use of one specific guide, *Exploring Magnetism on Earth*, and the challenges they encountered in using it. Feedback from their experiences in implementing the activities in *Exploring Magnetism on Earth* enabled the E/PO team to make revisions/improvements for the NASA products review and for teacher use in subsequent years.

Which Materials Are Being Used

GEONS teachers were questioned specifically about their use of three guides—*Exploring Magnetism on Earth*, the *THEMIS—GEONS User Guide* and *Exploring Magnetism (Grades 6-9)*—as well as PowerPoint presentations and the Problem of the Week. Six of the eight teachers confirmed they had all of these materials.

One teacher, who was new to the project, said that he did not have the *THEMIS—GEONS User Guide* and the PowerPoint presentations that had been distributed at the summer workshops. One teacher indicated he did not have *Exploring Magnetism (Grades 6-9)* and another teacher was unsure whether he still had the *THEMIS—GEONS User Guide*. All these teachers were promptly sent what they were missing.

In discussing their use of these THEMIS-related materials, teachers revealed...

The *THEMIS—GEONS User Guide* is of greater value in bolstering teachers' understanding of the project—Rather than using this guide with students directly, all six teachers having the guide reported that they use it for themselves in preparing student lessons and in making both formal and informal presentations to colleagues and other adults.

***Exploring Magnetism on Earth* and the PowerPoint presentations are most frequently used with students**—Five of the teachers reported currently using both the guide and the presentations for classroom instruction. Another two teachers plan to use *Exploring Magnetism on Earth* and one teacher is planning to use the PowerPoint presentations during the 2005-06 school year.

***Exploring Magnetism (Grades 6-9)* and the Problem of the Week are used nearly as often with students**—Both the guide and the Problem of the Week are currently being used by four of the teachers. Additionally, another teacher is planning to use *Exploring Magnetism* and two are planning to use the Problem of the Week during the 2005-06 school year.

In the course of the interviews, the teachers spontaneously mentioned additional THEMIS-related materials that they are using or plan to use. These other materials included...

- *Exploring the Earth's Magnetic Field (Grades K-12)* which two teachers are using for instructing students.
- *Exploring Magnetism (2004 version)* which one teacher is using.
- *Aurora Educator's Guide* which was mentioned by one teacher who is planning to use it in Modern Astronomy.
- *Exploring Magnetism in the Solar Wind* which was mentioned by two teachers, one of whom has specific plans to use it in Modern Astronomy.

How Materials Are Being Used

The GEONS teachers were asked to describe how they were using THEMIS-related materials. Specifically, the E/PO team wanted to know if teachers were integrating the materials into their curriculum or if they were using the materials as supplemental resources.

Seven of the GEONS teachers reported using the materials in a variety of ways depending on the course and grade level they were teaching. The one remaining teacher reported that although he has plans to use the materials, he had not yet determined whether he would be integrating them into his basic curriculum or using them as add-ons. Of the seven teachers currently using the materials...

Six GEONS teachers report integrating materials into their basic science curriculum—Six teachers reported that they are integrating THEMIS-related materials into nine of their courses—primarily in grades 10-12 in subjects such as physics, astronomy, geology and chemistry. Two of these teachers have also integrated the materials into general science at the 9th grade level and earth science at the 8th grade level.

Four GEONS teachers report using the materials as either add-ons or as stand-alone units—Three of the teachers reported using the materials as add-ons in 8th and 9th grade science courses, while one said she used THEMIS-related materials as whole units in high school astronomy and middle school science courses.

Using the *THEMIS—GEONS User Guide*. GEONS teachers are using the *THEMIS—GEONS User Guide* to reinforce their own understanding of terms and concepts and to share excerpts from the guide with more advanced students.

Of the eight GEONS teachers interviewed, six reported having copies of the *Guide*. All six explained that they primarily used the *Guide* for their own lesson preparation. Additionally, two of them said that they used parts of the *Guide* with more advanced students. Of the two remaining teachers, one who was new to the program did not have the *User Guide* and the other was unsure whether he still had a copy of it.

The *THEMIS—GEONS User Guide* was provided to all of the GEONS teachers in connection with the installation of the magnetometers at their sites. Teachers reported using the guide at the time of installation and referring to it when preparing presentations to the community, parents and other adults expressing interest in the magnetometer project.

I haven't implemented the *User Guide* this year yet...it pretty much gives basic background. It's more of a reference book for me...if I'm presenting something like 'how the magnetometer works.' Obviously I have some background material I can coordinate with. So I use it, but not taking the content directly. I'm using it more as just a reference... So it's more of an information guide for me, to give me some sufficient background to help explain what this whole project is focusing on—*GEONS teacher*

Using the *Exploring Magnetism on Earth Guide*. All GEONS teachers interviewed reported having *Exploring Magnetism on Earth* with five of them indicating they are using the guide with their students in current course work and two indicating they are planning to use its activities in their upcoming courses this school year. One teacher reported that although he had this new guide, he was not yet using it—this was the newcomer.

When teachers were asked to focus their attention on and to make general comments about the guide, *Exploring Magnetism on Earth*, they most often stated that they were most impressed with how well the activities are laid out and that even if students do something wrong, the activities still work. Overall, the teachers are positive about the guide and indicate that they select activities based on what is relevant and fits into their curriculum. Teachers mentioned that any reluctance they experience in implementing activities arises from the time commitment they perceive it will require to either prepare the lessons or perform the actual activities.

I decided to use the activities that I used because they fit so easily.... It's a general progression for freshman science to cover the topic. *Exploring Magnetism on Earth* dovetails right into freshman science with more bells and whistles—a little clearer, a little more direct. It gives you places to go; ties in things. It's a little better developed than some of the things you get from other sources—*GEONS teacher*

In general, GEONS teachers are most challenged by the limitations of their students in doing the higher math that is required for some of the activities or the lack of extracurricular tasks for those students who succeed in completing the basic activities. Occasionally, teachers lacked materials needed to complete activities.

The next main section presents an activity-by-activity close-up of the challenges GEONS teachers experienced in implementing each *Exploring Magnetism on Earth* activity. This feedback helped the E/PO team in revising the guide.

How Materials Are Disseminated

A critical task for the GEONS teachers is to let others know about the THEMIS project. The GEONS teachers' endeavors to do so have encompassed audiences in the general public as well as their own colleagues.

The high points of the teachers' efforts to 'spread the word' to a general public forum are...

- **Making formal presentations**—Four of the teachers reported either making or planning to make formal presentations at conferences and to their communities.
- **Working with the print media**—Four of the teachers were involved in working with the print media during magnetometer installations. These teachers conceded that since the installations they have not been diligent in continuing to attract the media's interest to the project—especially without a major event, like an aurora, to provide the lead.
- **Creating web links to THEMIS**—One teacher mentioned that a THEMIS project link on the school's Web site was another way that he has found to keep the project in the public eye.

GEONS teachers reported that sharing THEMIS-related materials with colleagues is most often done on an informal basis. Four of the GEONS teachers—in Alaska, Nevada, Oregon and South Dakota—said that they gave their colleagues THEMIS-related materials. Summarized below are the details these teachers provided about how these materials are being used...

- **Sharing with colleagues at all levels**—THEMIS-related materials are being shared with teachers from 3rd through 12th grades with most of the sharing happening at the middle level. Sharing with other middle school teachers is taking place at three of the four sites; sharing with high school teachers at 2 sites and elementary school colleagues at two sites.
- **Middle school sharing**—GEMS guides, THEMIS-related guides and materials and Power Point presentations are being shared in three locations with middle school science and earth science teachers.
- **High school sharing**—The Problem of the Week materials are being shared in two locations with high school math teachers.
- **Elementary school sharing**—THEMIS-related materials are being shared in two locations with elementary teachers. In one instance, the magnetometer is located across the hall from the elementary class.

Two GEONS teachers reported that they have shared THEMIS-related information on a more formal basis in in-services at their schools.

A Close-Up Look At *Exploring Magnetism on Earth*—Challenges and Revisions

The primary focus of the GEONS teachers' interviews was to gain an in-depth understanding of their experiences in implementing THEMIS-related guides, in particular, the activities from *Exploring Magnetism on Earth*. We were specifically interested in learning about the difficulties teachers encountered when using this guide. Our documentation of the challenges described by the GEONS teachers was then used by the E/PO team to revise *Exploring Magnetism on Earth*. These revisions were mandated by the NASA products review process as well as critically important in improving the guide for future use by GEONS teachers.

This section is divided into three sub-sections. The first two parts include background information—the first focusing on general findings about *Exploring Magnetism on Earth* activities and the second dealing with GEONS teachers' use of these activities. The final sub-section discusses teachers' concerns about their use of *Exploring Magnetism on Earth* and the E/PO team's response...

- General concerns in using activities from *Exploring Magnetism on Earth*
- Using activities from *Exploring Magnetism on Earth*
- Critique and revision of *Exploring Magnetism on Earth*

General Concerns In Using Activities from *Exploring Magnetism on Earth*

Generally, the E/PO team found that GEONS teachers were not comfortable trying new activities and sought ways to minimize their stress. After examining a detailed summary of GEONS interview findings, the E/PO team brainstormed with evaluators. The group noted that teachers tend to use the *Exploring Magnetism on Earth* activities with which they are most familiar. The E/PO team concluded that GEONS teachers tended to implement those activities they had learned at workshops, ignoring other activities in the guide that had not been addressed. Teachers mentioned that both a lack of time and confidence deterred them from dealing with new materials/activities that had not been modeled previously.

The E/PO team noted that teachers' stress over new material could be alleviated by providing a 'script' for the activities, thus less preparation time would be required on the teacher's part. It was also suggested that the E/PO team create additional overheads that could assist teachers in their preparation. These overheads could be included in a supplementary guide.

The E/PO team also discussed the idea of disseminating *Exploring Magnetism on Earth* and other materials beyond science courses. They felt that this would require the development of additional supplementary guides specific to non-science subject areas and incorporating skills used in these disciplines.

Using Activities from *Exploring Magnetism on Earth*

The purpose of this section is to provide detailed information on the extent to which GEONS teachers are using or plan to use the 17 activities in *Exploring Magnetism on Earth* during the 2005-06 school year. This section sets the stage for discussing teachers' challenges in implementing the activities and the E/PO team's responses to these difficulties that culminated in revisions to the guide—the topic of the next section.

Focusing on the use of activities, one teacher was unable to provide input because he was new to the project and had not yet used any activities or made plans to do so. The other seven teachers had used/planned to use anywhere from two to all 17 activities.

Figure 1 illustrates the percentage of activities from *Exploring Magnetism on Earth* that each of the seven teachers was using or planned to use in 2005-06. Percentages range from 18% to 100% of the 17 activities in the guide. Commendably, two teachers have managed to use/plan to use all 17 of the activities, with another indicating use of nearly 60%. Remember that interviews were conducted in February 2006, leaving ample time for additional implementation.

Initially we speculated that high use (teachers implementing a large percentage of activities) would be related to early magnetometer installation—five sites received magnetometers in phase 1 (2004-05), while seven got theirs in phase 2 (2005-06). However, the data do not support this conclusion—teachers B and D in Figure 1 got magnetometers in phase 2, while the rest received theirs earlier.

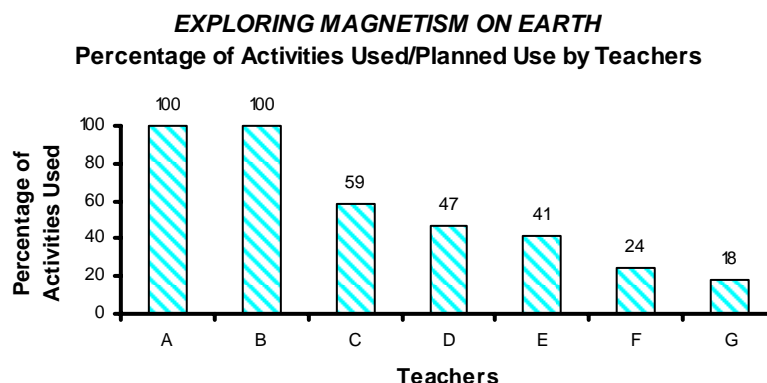


FIGURE 1. 2006 GEONS INTERVEIWS—Percentage of Activities Used/Planned Use by Teachers. Percentages of *Exploring Magnetism on Earth* activities that GEONS teachers are using/plan to use in the 2005-06 school year.—N=7

To gain an understanding of the extent to which each of the activities from *Exploring Magnetism on Earth* is being used or is being planned for use by the teachers, Figure 2, is offered for reference. This figure provides a summary of activity use—the activities are listed in the same order in which they appear in the guide. The activities address four main areas—‘magnetism and electromagnetism’ in turquoise, the ‘earth’s magnetic field’ in tangerine, ‘space weather’ in green and ‘magnetometer data’ in pink.

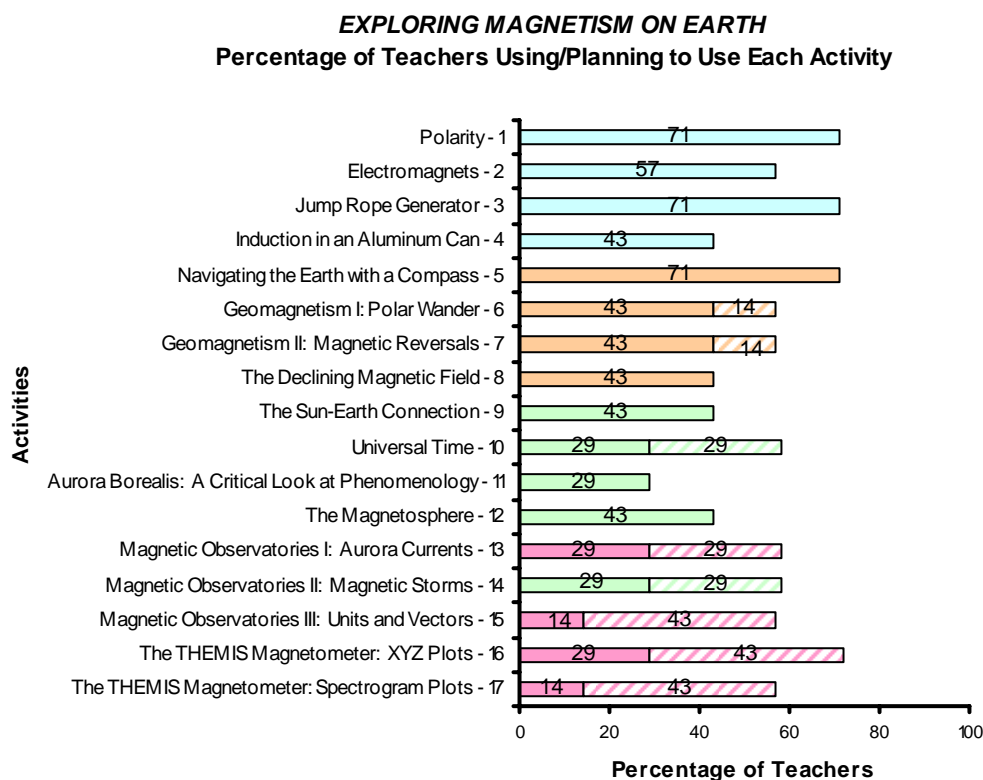


FIGURE 2. 2006 GEONS INTERVEIWS—Percentage of Teachers Using/Planning to Use Each Activity. Percentages of *Exploring Magnetism on Earth* activities that GEONS teachers are using/plan to use in the 2005-06 school year.—N=7

Table 2 corresponds with Figure 2 and summarizes the average percentages of teachers using/planning to use the activities in each of the main areas covered in *Exploring Magnetism on Earth*. Generally speaking, these areas increase in difficulty from top to bottom of the table—thus, the area of ‘magnetism and electromagnetism’ tends to have the least difficult material, while activities in the area of using the ‘magnetometer data’ require the most advanced math and science skills.

MEAN PERCENTAGE OF TEACHERS USING/PLANNING TO USE ACTIVITIES BY AREA			
Areas	Mean % of teachers using activities	Mean % of teachers planning to use activities	TOTAL
Magnetism and electromagnetism	61%	---	61%
Earth's magnetic field	50	7%	57
Space weather	35	12	47
Using magnetometer data	22	40	62

TABLE 2. 2006 GEONS INTERVIEWS—Average Percentage Of Teachers Using/Planning To Use Activities. Presenting the average percentage of teachers who, during the 2005-06 school year, are using or planning to use activities in each main area of *Exploring Magnetism on Earth*.

- **As subject matter becomes more difficult, actual use declines**—The second column from the left indicates that as the subject matter gets more difficult, the average percentage of teachers using the activities declines—with ‘magnetism and electromagnetism’ having the easiest material and 61% use and ‘magnetometer data’ requiring the most advanced skills and having only 22% use.

It is also true that GEONS teachers are more familiar with activities appearing earlier in the guide because they have had more exposure at workshops to these activities, and in contrast, they have had less exposure to activities toward the end of the guide. Thus, it follows that a greater percentage of teachers have used activities in the area of ‘magnetism and electromagnetism’, while fewer teachers have explored activities that appear later in the guide.

We anticipate that these percentages will look quite different when we interview teachers in 2007. By then, more time will have passed, increasing the opportunities for teachers to implement activities. In addition, all sites will have had magnetometers for at least one year by the time we interview GEONS teachers again.

- **Anticipated or planned use is high for activities dealing with ‘magnetometer data’**—The average percentage of teachers planning to use activities during 2005-06 was low—only 7% planned to use ‘earth’s magnetic field’ activities and 12% planned on using ‘space weather’ activities. No teachers reported planning to use ‘magnetism and electromagnetism’ activities. In stark contrast, however, is that 40% of the teachers planned to use activities dealing with the ‘magnetometer data’. This is not surprising since teachers will need to implement these activities in order to understand the data produced by their magnetometers.
- **On average, between half and three-fifths of the teachers are using or plan to use the four areas of activities**—For activities in the areas of ‘magnetism and electromagnetism’ and using ‘magnetometer data’, an average of 61% and 62% of the teachers, respectively, either used or planned to use the lessons in 2005-06. Almost as many teachers, on average 57%, were implementing or planned to implement activities in the area of the ‘earth’s magnetic field’. Finally, just under half of the teachers, 47% on average, used or planned to use lessons in the ‘space weather’ cluster.

Critique and Revision of *Exploring Magnetism on Earth*

This section of the report details the challenges that GEONS teachers said they encountered in using activities in *Exploring Magnetism on Earth* and presents the E/PO team's responses to these challenges which culminated in critical changes being made to the guide. These revisions were required by NASA's products review process and were necessary in order to improve *Exploring Magnetism on Earth* for use in subsequent years.

The E/PO team wanted to understand if the use of the activities in *Exploring Magnetism on Earth* was influenced by the guide's structure or the way it was written. They sought to understand how it could be made more usable. They also questioned whether the material was compelling and how to enhance its interest level for students. To find answers to these questions, the E/PO team closely examined the teacher feedback provided for the activities and discussed how the issues raised might be addressed.

To assist the E/PO team with their revision process, evaluators provided them with an in-depth summary of GEONS teachers' specific comments about *Exploring Magnetism on Earth* activities. Teachers' critiques of 12 of the 17 activities—those on which they offered substantive feedback—are presented in Table 3. This table presents teachers' concerns in four main themes along with the specific remedies that the E/PO team is making in order to address these criticisms. The four main themes are...

- Implementation
- Student skill level
- Cost of materials
- Teachers' content knowledge

Teachers' concerns about implementation included difficulties in translating concepts, using materials, making calculations correctly and getting through copious amounts of materials—for details see Table 3. In addressing teachers' concerns about implementation, the E/PO team developed unique solutions for each issue presented which included enhancing the translation of concepts, reorganizing and/or renaming activities, improving accessibility of data and introducing the concept of error analysis.

Activities for which students' skill level is a concern will be modified with more explanations and simpler presentations. In addition, the activities will be revised using the expertise of experienced teachers.

Concerns about cost will be easily handled by making teachers aware of opportunities for reimbursements.

Teachers' concerns about their own lack of content knowledge will be addressed by providing them with additional background information.

SUMMARY OF ISSUES AND REMEDIES FOR ACTIVITIES FROM <i>EXPLORING MAGNETISM ON EARTH</i>		
Activities	Concern—IMPLEMENTATION	Remedies
Polarity-1	Teacher felt activity could not be taught without the activity Electromagnets-2	Renamed 'Permanent Bar Magnets'. Created a better segue to Activity 2 as both activities involve polarity.
Induction in an Aluminum Can-4	Translation of the concept was difficult	Introduction modified to more clearly explain how the activity demonstrates Lenz's Law step by step. More detail is shown and explained on diagram illustrating how activity should be done.
Navigating the Earth with a Compass-5	There can be a steep learning curve using the compass.	Reviewed activity with teacher experienced in using this activity to determine if it needed to be streamlined.
Geomagnetism I: Polar Wander-6	Students get a different answer every time as well as differing from each other.	Included step with instructions to take an average all student measurements. Introduced error analysis into the activity. Picture was modified so that curvature of earth is more accurately represented. Use of wire is now suggested to aid in accuracy of measurements.
Universal Time-10	Calculations were difficult for the students	Divided into two activities, with first one focusing on reviewing the calculation of time zone differences.
Aurora Borealis: A Critical Look at Phenomenology-11	Going through the vast number of pictures of aurora was tedious.	Put a picture gallery on the THEMIS Web site to narrow the focus. Also, provided option to search the Internet. Reduced from 44 to 15 the number of items on the table studying the Great Aurora of October 2003.
Magnetic Observatories II: Magnetic Storms-14	The use of the data provided could be confusing leading to double-counting.	Reworked the activity to make it more user-friendly. Ensured there is an answer key. Incorporated teacher's successful technique of getting data from NOAA archive and showing plots on the wall around the classroom. NOAA Archive data from 2005 has been placed on the THEMIS Web site at a location created for that purpose. Link provided. Added Going Further section for students to enter data onto a computer datasheet posting data on wall in the classroom.
Activities	Concern—STUDENT SKILL LEVEL	Remedies
Magnetic Observatories III: Units and Vectors--15	Skill level of students needs to be high to do this activity, particularly math skills	Rewrite activity dividing into two parts, the first one being dedicated to vectors only. Provide more explanations.
The THEMIS Magnetometer: XYZ Plots-16	Skill level of students needs to be high to do this activity, particularly math skills	Redo plots to update them in addition to discussing with a teacher experienced with the activity how it might be made more accessible.
The THEMIS Magnetometer: Spectrogram Plots-17	Skill level of students needs to be high to do this activity, particularly math skills	Redo plots to update them in addition to discussing with a teacher experienced with the activity how it might be made more accessible.
Activities	Concern—COST OF MATERIALS	Remedies
Navigating the Earth with a Compass-5	Teacher reports orienteering compasses needed for Activity 5 are expensive.	Teacher advised to submit receipts for expenses.
Activities	Concern—TEACHERS' CONTENT KNOWLEDGE	Remedies
Magnetic Observatories I: Aurora Currents-13	Teachers not comfortable with their own knowledge level on this topic.	Provide more background material for the teachers. Complicated topic which will require creative thinking to address additional changes to be made.

TABLE 3. 2006 GEONS INTERVIEWS—Summary of Issues and Remedies. For each concern area—a list of issues raised by GEONS teachers about *Exploring Magnetism on Earth* activities and remedies suggested by the E/PO team.

Apart from providing these specific remedies for GEONS teachers' concerns, the E/PO team reflected on the organization of the guide itself. As a result, they decided to break the activities of the *Exploring Magnetism on Earth* guide into more meaningful and manageable segments.

There are now three guides, each containing an introduction explaining the connection among the guides as well as a brief explanation of the courses and grade levels for which the guide's activities are most appropriate. A fourth and final guide is being developed for students to use when working directly with the THEMIS magnetometer data.

Currently, the three guides are available on the THEMIS E/PO Web site ds9.ssl.berkeley.edu/themis by pressing the 'In the Classroom' button. These guides are...

Magnetism and Electromagnetism—This guide contains a review of basic magnetism and consists of the first four activities from *Exploring Magnetism on Earth* guide—'Polarity', 'Electromagnets', 'Jump Rope Generator' and 'Induction in an Aluminum Can'.

Exploring Magnetism on Earth—This guide is the second of the three activity guides which is intended to help students explore Earth's magnetic field through a variety of hands-on activities. This guide now includes activities numbered 5-8 from *Exploring Magnetism on Earth*—'Navigating the Earth with a Compass', 'Geomagnetism I: Polar Wander', 'Geomagnetism II: Magnetic Reversals' and 'The Declining Magnetic Field'.

Space Weather—As the third guide in the series, *Space Weather* introduces students to Earth's magnetic field and auroras in the context of the Sun and space weather. This guide offers activities from *Exploring Magnetism on Earth* numbered 9-12 and 14. One activity—'Universal Time'—is now two activities—'Review of Time Zone Mathematics' and 'Universal Time'. Additionally, the order of the activities for this guide is now—'The Sun-Earth Connection', 'The Magnetosphere', 'Review of Time Zone Mathematics', 'Universal Time', 'Aurora Borealis: A Critical Look at Phenomenology' and 'Magnetic Observatories II: Magnetic Storms'.

The remainder of the activities in *Exploring Magnetism on Earth* has required more extensive review and revision and will form the content for the fourth guide which is dedicated to working with the magnetometer data. These activities include 13 and 15 through 17—'Magnetic Observatories I: Aurora Currents', 'Magnetic Observations III: Units and Vectors', 'The THEMIS Magnetometer: XYZ Plots' and 'The THEMIS Magnetometer: Spectrogram Plots'.

The Future

Before the project draws to a close in 2008, the E/PO team will be completing and rolling out the fourth guide for the use of the teachers and will be continuing to provide the teachers with support in workshops, Yahoo! Groups and Problem of the Week. During this time, the GEONS teachers will have even more opportunities for working with one another and their colleagues as well as the E/PO team and will be gaining additional experience in using THEMIS-related materials and the magnetometers in their respective locations.

Before the end of the project, one final interview will be conducted with the GEONS teachers to learn about the progress they have made in their use and dissemination of THEMIS-related materials and the cumulative effects of continued interactions with the E/PO team, one another, their students, colleagues and the general public.