THEMIS—TIME HISTORY of EVENTS and MACROSCALE INTERACTIONS during SUBSTORMS

2004 GEONS Teachers Workshop

SUBMITTED—May 2005

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.

Seizing this opportunity, the THEMIS E/PO is in the process of establishing ten 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 schools is responsible for the magnetometer data and system as well as for using the data with students through lessons/activities developed for this purpose.

The network of 10 teachers and their students and magnetometers as well as students who participate using the web is called Geomagnetic Event Observation Network by Students (GEONS)—and GEONS is the centerpiece of the five E/PO activities of the THEMIS Mission…

- GEONS
- Teacher professional development at conferences
- Launch of GEMS site
- THEMIS Web site development
- Northern Lights Planetarium show

A critical part of the GEONS effort is the professional development for the ten GEONS teachers. These teachers receive informal guidance and materials (problem of the week) via e-mail and a Yahoo! Group. In addition, a more formal training workshop was held in the Summer of 2004 and another is planned for the Summer of 2005.

The focus of this report is to summarize questionnaire data collected from GEONS teachers attending the first of these formal workshops—a two-day training session in Berkeley, California in July 2004. A half-day session on the third day was spent exploring Chabot Space and Science Center.

The agenda for the workshop included the following presentations and activities…

DAY 1

- Overview of THEMIS E/PO
- Introduction to THEMIS Mission science
- Activities—magnetism, building magnetic bottle magnetometers, soda bottle measurements
- Introduction to magnetic storms, magnetic fields in the universe
- Introduction to professional magnetic data

DAY 2

- Mission science talk
- Activities—soda bottle measurements, exploring magnetism
- Magnetometer, installation and exploring magnetometer data
- Solar storm statistics, S.O.N. introduction

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DEMOGRAPHICS

Nine of the ten GEONS teachers participated in the July 2004 workshop in Berkeley, California. These teachers were from Alaska, Michigan, Montana, North Dakota, Nevada, Oregon, Pennsylvania, South Dakota and Wisconsin. The teacher from Vermont was unable to attend.

Demographic information is unavailable on all nine of these workshop participants. However, in January 2005, a subset of seven GEONS teachers was interviewed and demographic data were gathered at that time. Information about their school environments is summarized below…

- Most GEONS teachers work at rural schools.
- The majority of schools in which GEONS teachers work are middle and high schools.
- The average number of students in GEONS schools is slightly over 600.
- The average number of faculty in GEONS schools is slightly under 40.
- The average school district—for those having districts—is quite small; average size is 3,300 students.

Information about the teachers' educational backgrounds, teaching experience and current teaching circumstances is presented below…

- Nearly all GEONS teachers have undergraduate degrees in the sciences.
- The majority of GEONS teachers have science degrees beyond their bachelors.
- The average GEONS teacher has almost 17 years of teaching experience.
- Most GEONS teachers have been teaching for their entire careers.
- All GEONS teachers are teaching at the middle and high school level.

FINDINGS

At the end of each workshop day, GEONS teachers were asked to complete a questionnaire that presented both quantitative, rating scale items and qualitative, open-ended queries. These questions covered the following topics…

- Understanding of the NASA Mission/THEMIS E/PO
- Understanding of topics presented
- Lessons learned
- Anticipated use of materials
- Workshop likes, dislikes and suggested improvements

GEONS teachers' responses to these questions are presented in the remainder of this document.

Some questions that teachers were asked to rate dealt with their knowledge or understanding of specific areas both 'before today' and 'after the workshop'. In the 'before today' questions, teachers were asked to look retrospectively at what they felt their understanding or knowledge level was before the session. These responses are referred to in this section as 'start' of the day responses.

Responses reflecting the teachers' responses 'after the workshop' are described here as 'end' of the day responses. These 'start' of the day and 'end' of the day descriptions are used in Figures 1 through 3.

Understanding—NASA THEMIS Mission

The daily questionnaires asked GEONS teachers to use a 7-point scale to rate their understanding of…

- The NASA THEMIS Mission
- Their role in the THEMIS Mission
- Installation of the magnetometers

Their mean responses are graphed in Figure 1.

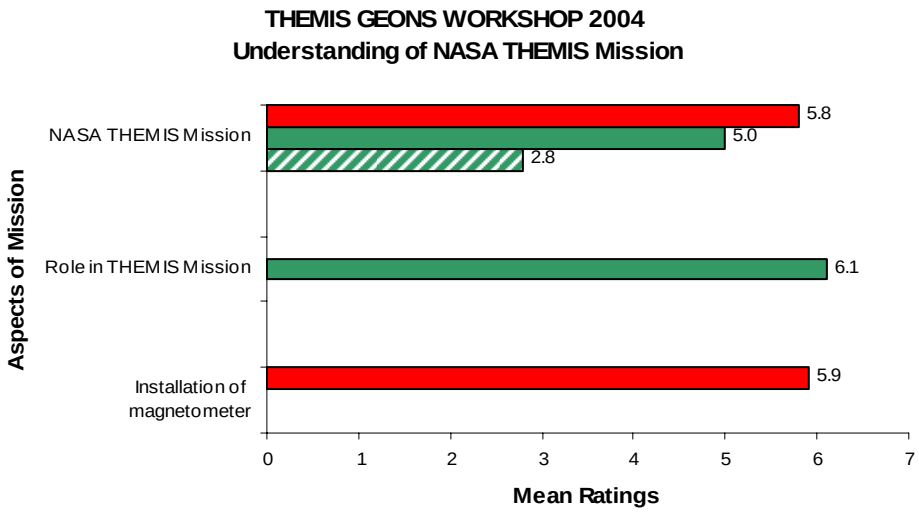

FIGURE 1. THEMIS—GEONS Workshop 2004. Mean ratings for perceived understanding of NASA THEMIS Mission (7-point scales)—N=9.

Striped Green—Start Day 1
Solid Green—End Day 1
Solid Red—End Day 2

Rating Scale Values Assigned—Only select points along the 7-point continuums were assigned values.

NASA THEMIS Mission
1=None
2=Novice
7-Expert

Role in THEMIS Mission and installation of magnetometer
1=Strongly Disagree
3=Somewhat Disagree
5=Somewhat Agree
7=Strongly Agree

GEONS teachers rated their understanding of the Mission, their role and magnetometer installation very high by the end of the sessions—By the 'end' of each day, the teachers' mean ratings (red and green solid bars) of their understanding of the Mission were 5.0 on the first day and 5.8 on the second day. These mean ratings were solidly between the mid-point of 4 and the top rating of 'expert—7'.

By the end of the sessions (red and green solid bars), teachers rated their understanding of what to expect in terms of the magnetometer installation and their role in THEMIS at a mean of 5.9 and 6.1, respectively. These ratings were solidly within one scale-point of the highest rating of 'strongly agree—7'.

GEONS teachers' understanding of the NASA THEMIS Mission increased greatly on the first day of the workshop and continued to increase on the second day—albeit less dramatically—When asked to rate their understanding of the NASA THEMIS Mission (striped green), at the 'start' of the first day, the teachers' mean rating at 2.8 was somewhat above the 'novice' point of 2 and substantially below the mid-point of the 7-point scale which is 4. However, after the session at the 'end' of the first day, their mean rating of understanding (solid green) grew to 5.0 representing a change of 2.2 points.

By the 'end' of the second session, the teachers' mean rating of understanding (solid red) increased an additional 0.8 scale-point to 5.8, for an overall growth of 3.0 points on the 7-point scale.

Understanding—Topics Presented

The daily questionnaires asked GEONS teachers to use a 7-point scale to rate their understanding of…

- Earth's magnetosphere
- Magnetometers
- Electromagnetism

Their mean responses are graphed in Figure 2.

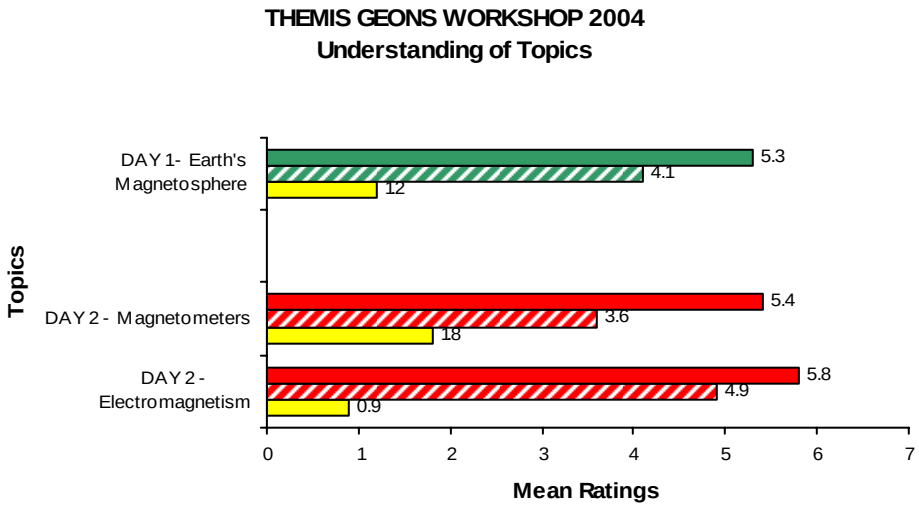

FIGURE 2. THEMIS—GEONS Workshop 2004. Before and after mean ratings and change scores for perceived understanding of various topics presented in the workshop sessions (7-point scale)—N=9.

Striped Green—Start Day 1
Solid Green—End Day 1
Striped Red—Start Day 2
Solid Red—End Day 2
Solid Yellow—Change

Rating Scale Values Assigned—Only select points along the 7-point continuums were assigned values.

1=None
2=Novice
7-Expert

Teachers rated their understanding of each of the topics very highly by the end of each session— The mean rating of the teachers' understanding of the Earth's magnetosphere at the 'end' of the Day 1 session (solid green) was 5.3—solidly above the 4 mid-point. For the Day 2 session, the 'end' of day mean ratings (solid red) for teachers' understanding of the magnetometer and electromagnetism were also solidly above the 4 mid-point at 5.4 and 5.8, respectively. In all cases, the 'end' of the day ratings were within about one- and one-half scale points from the highest rating of 'expert—7'.

Teachers' understanding of magnetometers started out lowest and increased most dramatically—After magnetometers were presented on Day 2, teachers' mean rating for their understanding of magnetometers at the 'start' of the day (striped red) was 3.6—lower than the other topics presented during the workshop sessions. However, after the 'end of the day, their mean rating for understanding of magnetometers (solid red) grew to 5.4—a positive change (yellow) of 1.8 points from 'start' to 'end' of the day. This positive change exceeded the changes for the other two topics with Earth's magnetosphere at 1.2 and electromagnetism at 0.9.

Teachers' understanding of electromagnetism started out at a higher level and increased least—The teachers' understanding of electromagnetism (striped red) as rated by them at the 'start' of the day resulted in a mean rating of 4.9—exceeding the mean ratings of the other topics. After the 'end' of the day, the mean rating change in understanding for electromagnetism proved to be the least of the three topics at 0.9 with Earth's magnetosphere at 1.2 and magnetometers at 1.8. It is not surprising that the highest start/end ratings and the least growth are related to a 'generic' topic—electromagnetism; and not an area specific to astrophysics and the project—the earth's magnetosphere and magnetometers.

Lessons Learned

The daily questionnaires presented open-ended queries asking GEONS teachers to list two things they learned in the workshop for that day. Tables 1 and 2 summarize teachers' comments from Day 1 (7/12/04) and Day 2 (7/13/04), respectively.

These comments are clustered according to themes that emerged when content was analyzed. For each thematic cluster, the percentage of teachers offering a comment in that cluster is provided. Because teachers were asked to list at least two things learned and some listed as many as three, the percentage of teachers who provided responses total more than 100% for each day's session.

While all nine of the teachers responded to the 'lessons learned' question on Day 1, only five did so on Day 2.

THEMIS GEONS WORKSHOP 2004 Things Learned in July 12, 2004 Session	Teachers (N=9)
Magnetic fields/magnetometers—How to use compasses to map magnetic fields; how to build a magnetometer and use it in the classroom; effect of solar winds on shape of earth's magnetic fields; effect of how the solar winds and magnetospheres interact.	67%
Purpose/scope of THEMIS Mission and teachers' role—Better what our role is in the mission and the scope it incorporates; theories about onset—ultimate question to be answered by THEMIS; getting to know my THEMIS mission colleagues better.	44
Auroras—Origin of auroras; two types of auroras; a substorm has stages—growth, break-up recovery	33
Scientific research—How competitive it is to pursue grant funding for basic science research; that relatively few schools/people applied to be part of the program	33

TABLE 1. THEMIS—GEONS WORKSHOP 2004. Percentages of teachers offering various responses to an open-ended question about things they learned on Day 1 of the workshop (N=9).

More than two-thirds of the teachers cited learning about magnetic fields and magnetometers— Learning about magnetic fields and magnetometers was cited by 67% of the teachers as one of the two things learned at the Day 1 session.

More than a two-fifths of the teachers cited learning about the purpose/scope of the THEMIS Mission and teachers' role—Learning about the purpose and scope of the THEMIS Mission and the teachers' role was mentioned by 44% of the teachers in the Day 1 session.

One-third of the teachers cited learning about auroras and scientific research—An equal percentage of teachers mentioned auroras (33%) and scientific research (33%) as being among the things learned in the Day 1 session.

THEMIS GEONS WORKSHOP 2004 Things Learned in July 13, 2004 Session	Teachers (N=5)
Science related to THEMIS—The magnetometer measures fluctuations in the magnetic field, not the actual field strength; the heat of the sun causes an East-West current that can affect the magnetometer; direct relationship between the Kp and aurora display; better understanding of the satellite (probes) through the visit to Manfred; nanotesla	100%
Ways to integrate Mission into classroom—Ways to incorporate this information into the classroom; possible activities to be used in my class	40
THEMIS hardware information—Instruments on the THEMIS probes—ESA, SST,EFI, SCM, FGM; requirements of magnetometer installation	40
Useful Web sites—SOHO and S.O.N. Web sites; some very good Web sites	40

TABLE 2. THEMIS—GEONS WORKSHOP 2004. Percentages of teachers offering various responses to an open-ended question about things they learned on Day 2 of the workshop (N=9).

All of the teachers mentioned learning about the science related to THEMIS—Of the 5 teachers responding to what they learned in the Day 2 session, all (100%) mentioned gaining knowledge about THEMIS-related science.

Two-fifths of the teachers cited that they learned about THEMIS-related Web sites, hardware and classroom activities—An equal percentage of teachers cited useful Web sites (40%), information about THEMIS hardware (40%) and ways to integrated the Mission into the classroom (40%) as things learned during the Day 2 session.

Anticipated Use of Materials

The daily questionnaires asked GEONS teachers to use a 7-point scale to rate their intention to use various THEMIS-related lessons and activities in their classrooms. These materials included…

- Solar storms and the aurora
- Exploring magnetism—Sessions 1 & 2
- Solar storm statistics

In addition, they were asked to use the same 7-point scale to rate their familiarity and 'know-how' with the following THEMIS components…

- S.O.N.—Student Observation Network
- Magnetometer

Teachers' mean responses are graphed in Figure 3.

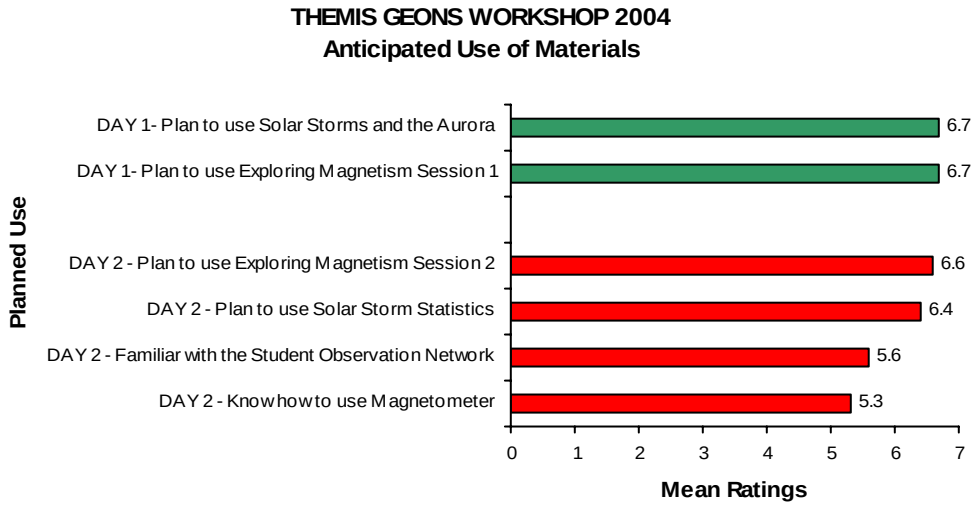

FIGURE 3. THEMIS—GEONS Workshop 2004. Mean ratings for anticipated use of THEMIS materials presented in the workshop sessions (7-point scale)—N=9.

Solid Green—End Day 1
Solid Red—End Day 2

Rating Scale Values Assigned—Only select points along the 7-point continuums were assigned values.

1=Strongly Disagree
3=Somewhat Disagree
5=Somewhat Agree
7=Strongly Agree

Teachers overwhelmingly agreed that they intended to use the materials related to Solar Storms and Exploring Magnetism—The mean ratings for teachers' anticipated use of materials related to Solar Storms (6.7 on Day 1 and 6.4 on Day 2) and Exploring Magnetism Session (6.7 on Day 1 and 6.6 on Day 2) were all within about half a scale point from the highest rating of 'strongly agree—7'.

Teachers indicated that they are slightly more familiar with the Student Observation Network than knowing how to use the magnetometer—The teachers' mean ratings for their familiarity with the Student Observation Network at 5.6 was slightly greater than their knowledge of using the magnetometers at 5.3—both of these mean ratings falling about half-way between the mid-point of 4 and the highest scale point of 'strongly agree—7'.

Workshop—Likes

The daily questionnaires presented open-ended queries asking GEONS teachers to list what they most liked about each session. Tables 3 and 4 summarize teachers' comments from Day 1 and Day 2, respectively.

These comments are clustered according to themes that emerged when content was analyzed. For each thematic cluster, the percentage of teachers offering a comment in that cluster is provided. Multiple responses result in percentages totaling more than 100% for the Day 1 session, while rounding accounts for the Day 2 percentages being slightly less than 100%.

All of the teachers responded to this question on both days.

THEMIS GEONS WORKSHOP 2004 MOST Liked about July 12, 2004 Session	Teachers (N=9)
Activities—Mapping the magnetic field; the hands-on activities we did; numerous activities kept us engaged in an active manner; hands-on stuff	44%
Ways to integrate Mission into classroom—Finding out how this will work in my classroom; providing us with materials we can use in our classrooms	33
Interactions with colleagues and experts—Interacting with other science teachers and experts in the field; input we were able to give; listening to experts in scientific field	33
Expanding teacher's universe—'Magnetic Fields in Universe' talk—food for thought beyond my understanding	11

TABLE 3. THEMIS—GEONS WORKSHOP 2004. Percentages of teachers offering various responses to an open-ended question about what they liked MOST on Day 1 of the workshop (N=9).

Over two-fifths of the teachers reported liking THEMIS-related activities the most—Activities related to the THEMIS Mission were cited by 44% of the teachers as being what they most liked about the Day 1 session.

Information about implementing the Mission and having time to interact with colleagues and experts tied for second with one-third of the teachers liking them most—Ways to integrate the Mission into the classroom were cited by 33% of the teachers as being what they most liked about the Day 1 session, while another 33% cited interactions with colleagues and experts.

One teacher most liked having his universe expanded—One teacher, representing 11% of all respondents, indicated that having his universe expanded was what he most liked about the day's session.

THEMIS GEONS WORKSHOP 2004 MOST Liked about July 13, 2004 Session	Teachers (N=9)
Field trip—The tour to see the satellite data; Mission Control—cool!	33
Materials/activities/ways to integrate THEMIS into classroom—The activities were very useful; the S.O.N. activity and introduction; discussion about how this work can incorporated in our classes; solid copy of information	33
Positive comments—Everything was great! Introduction to Web sites especially; I feel more like I understand what will be happening and expected from me and my site from the magnetometer box itself	33

TABLE 4. THEMIS—GEONS WORKSHOP 2004. Percentages of teachers offering various responses to an open-ended question about what they liked MOST on Day 2 of the workshop (N=9).

Teachers were equally divided in their comments—The same percentage of teachers (33%) mentioned each theme cited for the Day 2 session—the field trip, materials/activities/ways to integrate THEMIS into the classroom and positive comments.

A third of the teachers used this opportunity to praise the workshop—Positive comments about the workshop came from 33% of the teachers. These comments included teachers gaining a better understanding of what will be expected of them, introduction to Web sites and the workshop being 'great'.

Activities and ways to integrate the mission were again cited as being most liked—Echoing a theme from Day 1 (see Table 3), 33% of the teachers on Day 2 cited the materials/activities/ways to integrate THEMIS into the classroom as being what they most liked.

Workshop—Dislikes

The daily questionnaires presented open-ended queries asking GEONS teachers to list what they least liked about each session. Tables 5 and 6 summarize teachers' comments from Day 1 and Day 2, respectively.

These comments are clustered according to themes that emerged when content was analyzed. For each thematic cluster, the percentage of teachers offering a comment in that cluster is provided. Due to rounding, percentages do not sum to exactly 100%.

While eight of the teachers responded to the 'dislike' question on Day 1, all teachers did so on Day 2.

THEMIS GEONS WORKSHOP 2004 LEAST Liked about July 12, 2004 Session	Teachers (N=8)
Comfort issues—The room was a little chilly: Lavar's Pizza is poisonous; jet lag	38%
No issues—None; not really; not applicable	38
Time management issues—Sessions were a little long and I'm feeling bone tired; the time it took to set up the pop bottle magnetometer	25

TABLE 5. THEMIS—GEONS WORKSHOP 2004. Percentages of teachers offering various responses to an open-ended question about what they liked LEAST on Day 1 of the workshop (N=9).

Over three-quarters of the teachers either had no dislikes or commented on their personal comfort—An equal number of teachers said they had no dislikes (38%) or cited comfort issues (38%) when asked about what they least liked about the Day 1 session.

A quarter of the teachers commented on time management concerns—Time management concerns were raised by exactly 25% of the teachers who noted that they felt too tired for such long sessions and that some activities took too long to implement.

THEMIS GEONS WORKSHOP 2004 LEAST Liked about July 13, 2004 Session	Teachers (N=9)
No issues/all positive—None; nothing; all was positive	44%
Workshop structure and content—Seemed very compressed and disjointed. My confusion index was going up in the afternoon; video at 2 p.m. (difficult time to stay focused); the VHS…and loud snoring	33
Comfort issues—It felt colder; a little tired from the night before	22

TABLE 6. THEMIS—GEONS WORKSHOP 2004. Percentages of teachers offering various responses to an open-ended question about what they liked LEAST on Day 2 of the workshop (N=9).

Two-fifths of the teachers commented that they had no dislikes—When asked about Day 2 of the session, 44% of the teachers said that they had no dislikes and, in fact, some indicated that it was all positive.

A third of the teachers commented on the workshop structure and content—Comments about the workshop structure and content were made by 33% of the teachers after Day 2 of the workshop.

A little less than a quarter of the teachers again cited their personal comfort—After the Day 2 session, 22% of the teachers cited issues related to their personal comfort, repeating a concern voiced by 38% of the teachers after the Day 1 session (see Table 5).

Workshop—Suggested improvements

The Day 2 questionnaire presented an open-ended query asking GEONS teachers to suggest improvements to the workshops. Tables 7 summarize teachers' comments.

These comments are clustered according to themes that emerged when content was analyzed. For each thematic cluster, the percentage of teachers offering a comment in that cluster is provided. Multiple responses result in percentages totaling more than 100% for the Day 2 session.

All of the teachers responded to this question.

THEMIS GEONS WORKSHOP 2004 Suggestions for Next Workshop from July 13, 2004 Session	Teachers (N=9)
Increase opportunities to share/collaborate—Share lesson plans on Web site; have participating teachers come with activities to present/share to give us more ways to use the program; collaboration on data integration and subject integration in classroom; ;bring in scientists to review the how and why so we can ask questions and fill in areas in which we may develop questions throughout the year	44%
Modify workshop structure—Decompress the sessions—10 hours of seminar, no matter how pleasant, is draining; one day longer	22
Hold winter workshop—Winter workshop? More chance to observe auroras…in Alaska!	22
Provide more ways to use the magnetometer data—More ways to utilize the magnetometer data; develop lesson plans using the magnetometer data	22
Increase communications—Updates on the progress of the mission and changes, the evolution of the program	11

TABLE 7. THEMIS—GEONS WORKSHOP 2004. Percentages of teachers offering various responses to an open-ended question concerning suggestions for the next workshop (N=9).

Teachers' top suggestion was to increase opportunities to share/collaborate—The most often cited suggestion, which was made by 44% of the teachers, was to increase opportunities to share/collaborate.

Modifying the workshop structure, holding a winter workshop and providing more ways to use the magnetometer data, shared the second spot—Drawing the response of an equal percentage of teachers (22% each) were the suggestions to modify the workshop structure, to provide more ways to use the magnetometer data and to hold a winter workshop.

Increasing communications was suggested by one teacher—One teacher, representing 11% of the respondents, suggested increasing communications from program leaders to the GEONS teachers.

Workshop—Additional Comments

Teachers were asked to share any additional comments they might have after both sessions. No teacher responded to this question after Day 1, while six of the teachers provided comments after Day 2. Table 8 shows thematic clusters and percentages.

THEMIS GEONS WORKSHOP 2004 Additional Comments from the July 13, 2004 Session	Teachers (N=6)
No issues/Positive comments—Thanks for a good conference—great speakers and motivators; no additional comments; very informative; definitely a positive experience—I feel much more comfortable with this project	67%
Teachers need to be a support network—The biggest thing for this project to succeed, I believe, is for teachers to stay connected via e-mail as a support network for each other: I need to hear success stories from other teachers	33

TABLE 8. THEMIS—GEONS WORKSHOP 2004. Percentages of teachers offering additional comments (N=9).

Two-thirds of the responding teachers gave accolades or said they had no additional comments—The responding teachers who said that they either had praise and thanks for the workshop or that they had no additional comments represented 67% of the respondents.

A third of the teachers commented that they needed to form a support network—Suggestions that the project can best succeed if teachers provide a support network to one another drew comments from 33% of the teachers.