Perspectives on Deepening Teachers' Science Content Knowledge: The Case of the Michigan Teaching Excellence Program

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Abstract
The Michigan Teaching Excellence Program (MiTEP) is a partnership between Michigan Technological University, Grand Valley State University, Grand Rapids Area Pre-College Engineering Program, and the Grand Rapids Public School District, targeting 15 teachers of middle grades earth sciences in its first year. Teachers engage in two weeks of summer field studies with supporting lectures; the primary goals are to deepen teacher disciplinary content knowledge beyond the level expected of their students, and to enhance teacher understanding of the nature of scientific inquiry. To facilitate teacher application of their enhanced content knowledge in their classrooms, the project selected experiences that relate to both the state's content expectations for earth science education and to geology features encountered locally by the district's students. Project team members are expected to model appropriate pedagogical practices throughout the professional development, including requiring learners to provide evidence to support their claims, and encouraging them to reflect on their emerging understanding of earth science concepts in daily journals. In addition, one day during the first week and two days during the second week are designated as pedagogy days, where teachers adapt the learned content to district adopted pedagogical norms and models, including the Disciplinary Literacy framework developed by the Institute for Learning at the University of Pittsburgh. Finally, in response to participants' requests, project staff are developing classroom activities similar to those the teachers experienced, but at a level appropriate for middle grades students.

Context of the Story

The groundwork (literally) for the Michigan Teaching Excellence Program (MiTEP) was initiated by an upwelling in the asthenosphere, when a hot mantle plume created tensional stress in the earth's crust at a near-90 degree bend in the mid-continent rift system located in North American tectonic plate. The resultant divergence of the crust created a rift valley, and continued stress on the thinned crust produced fissures and faults, creating pathways for hundreds of individual massive basaltic lava flows, some as thick as 25 km. Aqueous solutions of minerals were heated as the massive basaltic lava oozed through the fissures. Just as the temperature had cooled to around 400 degrees C, intense compression forced rivulets of red/orange metal dissolved in superheated steam to permeate the faulted, fractured lava flow in an upward, cooling ascent. In the absence of sulfur, the red/orange metal solidified in its elemental state. Rivers of copper metal were frozen in place, some protruding from the base basalt, others waiting to be exposed by glaciation, erosion, and extraction by humans.

Nearly 1.1 billion years later, fifteen Grand Rapids (MI) public school teachers are learning about these geologic events through the guidance and tutelage of an instructional team assembled to support the MiTEP MSP, comprised of earth scientists from Michigan Technological University and Grand Valley State University, assisted by several graduate students. Most of the 15 participants in this professional development initiative are teachers of middle school Earth science, and among these are some who have considerable content knowledge supporting their work as teachers of Earth system science, while others have a more limited background in this content area. This cohort of teachers represented all of the eighth grade Earth science teachers in the Grand Rapids Public Schools who had submitted applications for the first year of the project, which provided a modest stipend, on-campus housing and meals, and 4 graduate credits from

Michigan Tech. MiTEP planned to offer a two-week field study for teachers in the summer of 2009, in the belief that in order to effectively teach geology, teachers needed to get a sense of the nature of the discipline, which typically involves extensive field work.

To help in designing the initiative, project staff collected survey data on participants' curriculum content and pedagogical preparedness in topics found in Michigan's Earth science standards and administered a pre-test targeting common Earth science misconceptions. Project staff then worked to create field experiences and supporting resources linked to identified participant needs, science content standards, and the intended curriculum objectives prescribed by the district-adopted text, *EarthComm*.

Our design included the purposeful infusion of pedagogical practices, scientific habits of mind, and leadership initiatives, all situated in, and serving to reinforce, the targeted content learning. Clearly, this multifaceted initiative was to require a comprehensive and well-coordinated effort among the members of the instructional team and school and district stakeholders.

Four components of the MiTEP implementation strategy provide the foundation for the work being done.

- *Articulation of a common vision of curriculum reform.* Teachers play a critical role in determining the curriculum in terms of its content, scope, sequence, and delivery. Teachers must share reform goals if changes are to succeed.

- *Development of curriculum that is aligned with the district goals, as well as state and national standards*. The National Standards provide the framework for alignment that are articulated in Michigan primarily through the Michigan Curriculum Framework [1991] and the Michigan Merit Curriculum [2007]. The broad goal is scientific literacy for all, with an emphasis on teaching for understanding of major scientific concepts, rather than coverage of extensive content.

- *Enhancement of teachers' content knowledge and skills in using inquiry in the classroom to initiate, evaluate, and sustain reform.*

- *Improvement of student learning outcomes in terms of knowledge and skills with a focus on meeting state and national grade-level performance targets in science.*

The Professional Development Experience

As stated in the MiTEP proposal:

> *Earth science is the ideal venue for infusing inquiry into classroom-based instruction because it encompasses a multitude of real-world examples that can be investigated by students at any site. In many schools throughout the nation, earth science is taught in the middle grades where it is typically students' first full course in science. The proposed project is based on the hypothesis that middle-school earth science is pivotal in students' science education because students' perceptions about science in general are likely to be*

strongly influenced by their first intensive course. This proposal therefore describes a suite of interventions designed to improve the quality of earth science instruction in the middle grades, and a plan to evaluate the effectiveness of those interventions. Teachers are at the center of the proposed project as they are critical to the long-term success of school improvement efforts. Middle-school earth science teachers are in an ideal position to conceptualize and lead longitudinal curriculum reform efforts because they have the perspective necessary to ensure that childrens' science education is appropriately scaffolded from the primary through the high school grades.

Michigan's science standards include eighth grade in the *High School Content Expectations*. This placement has led to a quandary for many of the state's school districts, as they consider selection and adoption of content and associated delivery strategies at grade eight. Some Michigan school districts, like the Grand Rapids Public Schools, have adopted Earth science as an eighth grade requirement. However, because high school science content standards drive instruction in this course, many districts have adopted high school textbook packages. Such is the case in Grand Rapids, where the high school text *EarthComm* was adopted by the district to support enactment of the eighth grade Earth science curriculum.

Among the challenges faced by the Grand Rapids Public Schools and other districts in responding to Michigan's state curriculum are: 1) the difficulty level of the high school curriculum for eighth grade students, and 2) the possible inadequacy in content background and preparedness of the district's teachers to deliver this curriculum. These critical issues underscore the importance of MiTEP and provide the backdrop against which the activities of the project have been created.

Teachers participate in the MiTEP project for three years. The primary content enrichment strategies are summer field studies and supporting lectures; the goal is to provide teachers with hands-on, inquiry experiences related to both the curriculum and to geology and Earth science features encountered locally and throughout the state by their students. Because the state of Michigan is divided into two separate peninsulas having almost entirely different geological features (generally referred to as the "Upper" and "Lower" Peninsulas), each two-week summer session is split, with a session conducted in Michigan's Upper Peninsula and the other session conducted in the Grand Rapids area of the Lower Peninsula. Months in advance of the two week summer field study, a survey was distributed in which participants identified their relative levels of core knowledge, teaching comfort and their students' preparedness in topics taught at their grade level in Earth science. Priorities were established and the itinerary for the 6 days in the field was established with the priority topics woven into the daily schedules. Among the highest priority topics identified on the surveys were landforms, Earth resources, energy sources, interaction among Earth's systems, and Earth history, all topics that are central to the earth sciences curriculum. Some of the field days involved significant travel, so despite establishing a daily over-arching question chosen from among the priority topics, the actual sites visited sometimes included activities or content that created a better fit with a different priority topic. A choice was made to assess these opportunities and to include those that either afforded significant inquiry potential or that provided substantive links to other learning.

Earth history serves as the focal point of this story. What follows is a synopsis of one day in the "life" of the MiTEP project. Through this lens, the reader can gain a vision of the constructs of

the daily routine experienced by the teachers, including an understanding of the interplay among acquisition of content knowledge, pedagogical awareness, and use of inquiry strategies.

MiTEP Day Two

The professional development program began with a brief welcome by the MiTEP instructional and executive staff followed by introductions of the participating teachers. Workshop logistics were shared (where and when meals would be served, campus orientation, forms to be completed, etc.), and an Earth science content pre-test (MOSART) was administered. The PI then provided a brief introduction to Upper Peninsula Michigan geology, with suggestions regarding features to look for as we prepared to embark on our first day of field study. Field journals were distributed and the participants were encouraged to document the day's activities in whatever format they considered scientifically "appropriate." The participants were also each furnished with a loaned laptop computer, a portable Global Positioning System (GPS), and a short demonstration showing how GPS data could be collected in the field and later exported to the laptop computer. Critical GPS functions included setting "waypoints" (identifying and logging particular locations on the GPS electronic map) and "tracks" (creating and saving, on the GPS electronic map, trails showing movement over time). The afternoon field study that followed provided the participants with a very general orientation to the local geology and topography, and also gave them an opportunity to practice journaling and collecting and interpreting data with the GPS units. At the end of the day, the participants turned in their completed journals, which were studied by the instructional staff with the purpose of identifying an approximate baseline norm. Notes of encouragement were added to each journal by the instructional staff.

At the beginning of the second morning (as in every subsequent morning) the teachers were presented with an over-arching question, a list of objectives, and background information to focus the day's learning. Based upon the journal inspection the previous night, project staff established a rubric for future journal entries. Teachers were asked to include observations, data tables and illustrations of the day's activities, and relevant questions. At the end of the day, each teacher wrote a formal response to the over-arching question in their journal, including an answer to the day's stated *problem* as a *claim*, citing *evidence* they collected during the day, and an explanation of the teacher's *reasoning* relating the claim and evidence to the stated problem. Teachers were also asked daily to propose further scientific research, suggesting an additional question that they thought would be interesting to investigate.

Today's over-arching question (actually a series of questions) was:

> *What role do microbes play in forming geologic deposits? How can biological and sedimentological features in rocks tell us about Earth's ancient environments? How do we know how old rocks are? How does this very different, very ancient environment inform our current understanding of living on earth?*

As the participants considered the day's over-arching question, they asked several clarifying questions and raised some procedural issues. When these had been addressed, one of the PIs provided a 40-minute description of the content background related to Earth history that would be the focus of the day's activities. This "content before activity" strategy was not viewed as ideal, but was deemed necessary due to the transportation conundrum of two vehicles and one

local geology expert. It was decided that coordination could best be accomplished by alerting the drivers and the participants of landmark features *before* departing.

The boxed section that follows (Sample of Daily Plan), along with a similar description for each field day had been given to the teachers at the beginning of the course in a notebook, along with a laptop computer and a GPS unit for their use during the two week course. The teachers were provided with a course web page, printed journal articles, and a textbook, *Michigan Geography and Geology* (2008, Schaetzl). In addition to the brief introduction by the PI, the teachers were provided with background information about every location we planned to visit during the course, either in written form or electronically on the web page.

Daily Plan for Day 2:[1]

Day 2: Black and Red rocks: Calumet, Eagle River and (mainly) Horseshoe Harbor

Problems: What role do microbes play in forming geologic deposits? How can biological and sedimentological features in rocks tell us about earth's ancient environments? How do we know how old rocks are? How does this very different, very ancient environment inform our current understanding of living on earth?

Necessary Background Information: Schaetzl Ch 12

- Earth history timeline; Deep time, unconformities.
- Basic divisions of rocks (igneous, metamorphic, sedimentary)
- Rift geology, red and black rocks
- Derivation and transport of sediments
- Formation of sedimentary rocks: clastic versus chemical
- Basic mineralogy: quartz, feldspar, "other"
- Rodiniaand the Keweenaw rift
- Oxygen, snowball earth, paleomagnetism
- "Reading" rocks, sedimentary environments, alluvial fans, debris flows
- Sedimentary features
- Stromatolites—an index fossil?
- Radiometric dates
- Fossils and the fossil record
- Potholes and scaling a river
- Energy and grain size in sediments
- Basic tools: topographic maps, geologic maps, compass, hand lens, acid, hammer

Roots and links:
It is linked to the following parts of Michigan's Earth Science *High School Content Expectations*: E2.1B, E2.2F, E2.4C, E3.p1B, E3.p3B, E 3.3A, E3.4A, E4,p3C, E4.1A, E5.3B, C, D, E5.3e,g, E5.4f.
This day relates to Units 1, 5, 6, and 7 in District learning outcomes for Science 8.
The sources for web based linkages are on your laptop under **Day 2**.

Required Materials: Topographic map and air-photos of Copper Harbor area, field notebook, ruler, compass, hand lens, Jacob's staff, acid bottle, grain-size charts, pencils and erasers, lunch, sunscreen, hat, lots of water.
Spreadsheets: Geological time and Stratigraphic section

Activities in the Field:
Beach profile description, compare with Great Sand Bay; Geologic mapping; strike and dip; Compiling a rock section; Visualizing geologic time; Mineral and contact identification; Paleoenvironment identification; Field sketching and note-taking; Reading the rocks; Cyanobacteria in fossil and living form.

Hints and Other Things to Consider - *You don't have to answer any of these questions specifically, but thinking about them will help you to formulate a response to the problem*:

1. How do we know that stromatolites were once alive? What does the presence of cyanobacteria mean in this context? When were these clastic sedimentary rocks deposited (i.e., how old are the rocks), in millions of years? What kinds of rock are included in the conglomerate? What is the significance of the red color of the Copper Harbor formation (and Freda and Jacobsville Sandstones)? Where are older rocks exposed in Michigan that might have supplied sediments to these deposits? Is it possible to determine what happened here between the Precambrian and the Pleistocene? What process(es) formed the Precambrian/Pleistocene contact we see today? What does the contact at Eagle River represent, with respect to rifting? Are any places on earth devoid of life now? Does the Keweenaw Rift basin have anything to do with Lake Superior? Where would you go, and what would you study, to gather additional information about these questions? Was the climate colder or warmer at the time the Copper Harbor Conglomerate was deposited? Are the geologic maps or the air-photos of the area helpful?

[1] The structure of MiTEP's Daily Plan is a modified version of the daily plan Dr. Jacqueline Huntoon developed for Michigan Technological University's Geology of Utah's National Parks field course (Huntoon et al., 2009).

Anticipated Outcomes - *As a result of the day's activities you may be able to do the following*:
Learn how to make sketches of geologic features.
Learn how to "read" rocks, especially sedimentary environments.
Learn how to use a Brunton-type compass and hand lens.
Learn how to take field notes.
Identify transitions, or contacts between different rock units.
Identify quartz, feldspar and other minerals in rocks.
Identify sedimentary structures and trace fossils in sedimentary rocks.
Interpret depositional environments from sedimentary rocks.
Relate sedimentary rocks to a source region.
Understand links in geologic and biologic systems.
Understand geological time, radioactive decay and geological age dates

Following the morning's preparatory remarks, the participants convened in the parking lot for departure. Two Michigan Tech vans, pre-loaded with equipment and supplies for the day's field study, awaited departure. Participants had packed their GPS receivers and laboratory journals. The data collected by the GPS units would later be exported to laptop computers, where detailed satellite images of the visited sites would be overlain with user-selected points of interest and electronic tracks of whatever meandering trails they had followed. The instructional staff strategically distributed themselves in the two vans to provide optimized content expertise during the travel segments. Although the focus of this day's activities was to be "Earth history," the participants were asked to consider the general theme of "evidence" that runs throughout the course as they journeyed to the first scheduled stop. Thoughts on the subsequent field study will be provided through actual participant reflections, borrowed from their journals and revealed in interviews.

Earth science field work was new to most of the participating teachers, and in some cases the very notion that the Earth was billions of years old conflicted with what they had learned in religious instruction, so there was a fair amount of anxiety among participants. Ruth[2] describes her initial trepidation in her journal:

> *First of all, at the start of the day I was just so confused. Throughout my formative years the* Bible *was taught to me, and I was indoctrinated that the Earth is only in the thousands of years old… and that was that! Science didn't really exist in my brain, especially Earth Science. As I've grown older, experiences have taken me to various things/places to see my prior teachings conflict with what I see. Talk about two plates" converging!*

The first stop on the journey had been included to provide the participants with evidence of the effects of glaciations on the region. The teachers were shown glacial grooves on a basalt bedrock outcrop exposed near a school that was built on the former site of the Calumet and Hecla Copper Mine. The PI described how glaciologists can interpret the direction of glacial movement from the grooves. Ruth reflects in her journal:

[2] Names have been changed to provide anonymity.

> *First, at the mine place, I saw effects of glaciers retreating. Looking at the striations (grooves) I could see where boulders were dragged and the shadow zone showed me the direction the glaciers retreated. This shows (gives evidence) of some great amounts of energy present to cause these boulders & striations.*

The next stop on the field study was a scenic waterfall. After the teachers had taken a few minutes to observe the site and consider how it might relate to the over-arching question of the day and to search for evidence, the discussion turned to differences in the formation of igneous basalt rock from lava flows and sedimentary sandstone formed through marine deposition. The PI used this site to describe how geologists can interpret simple evidence ("where the black rocks and the red rocks meet") and to create detailed interpretations through the same "claim/evidence/ reasoning" strategies that are employed by these teachers in their classrooms. Questions and discussions related to age dating, the "tilting" of the rocks and the geometries of their structures, the formation of Lake Superior, and other observations were made by the teachers at this site. Ralph includes the following statement in the "evidence" section of his journal:

> *Understanding past conditions (water energy, wind energy) may be better understood by reading cross sections of or profiles of a rock formation like the ones visited today.*

Nearly an hour of travel separated the travelers from their next learning venue; Horseshoe Harbor near the "tip" of the Keweenaw Peninsula. The van trip along Lake Superior stimulated small group discussions of the area's visual features and interpretations that geologists have formulated describing these features. As the journey continued, rather than answering the teacher questions, staff tended to deflect them with probing, response questions. Some participants indicated frustration with this approach, but as Ruth recalled in a post-workshop interview:

> *I don't think we were frustrated with what was being presented; I think we were frustrated with how it was being presented. But [this] was actually good in the long run- how it was done. Because we are adults we need to learn things and not always know… When I first got out of the van and someone asked "which way is up?" and I thought I should just go home, go south. I felt out-leagued immediately. But anyway, even if you knew all the answers, you could still learn how to present it.*

Upon arrival near Horseshoe Harbor, participants exited the vans, slathered on insect repellant and sunscreen, and assisted in transporting equipment and lunch through a narrow walking trail to a remote beach setting. Following lunch on the beach, a human "timeline" was created along the beach front to emphasize the scale of Earth history. This visual and graphical representation was accompanied by much enthusiasm.

The participants were then divided into groups which would rotate among three specific activities; a beach profile, a pebble count, and observation of a stromatolite bed. The beach profile and pebble count contributed to their understanding of the sedimentology aspects of the over-arching question, while the observations of the stromatolite bed provided evidence related to the microbial effects, the question of the age of the Earth, and clues about how ancient life differs from life today. Ruth describes her epiphany as a result of the activity:

And we saw where the cyanobacteria were growing. In the conglomerates we saw, we observed the layers, and the layers tell us there were bacteria (life). Also, for this bacteria to live it photosynthesized, which means there was oxygen, which of course provided life then for <u>anything</u>, and eventually we "came along!"

Day 2 Pictures at Horseshoe Harbor on the Keweenaw Peninsula:

Teachers Making a Geologic Timeline

Teachers sampling size of beach particles and correlating that to distance from shoreline.

Teachers measuring distance from shoreline and height of beach to sketch a beach profile.

At the conclusion of her journal entry, Ruth recorded the following passage:

Mostly, what today showed me was that there was life long, long ago, as in billions of years, and that life is still evolving, along with our understanding. I have too many further questions to list, but for now I just want to observe and absorb.

Ralph's journal included the following entry under *Evidence*:

-In the fossils records we find cyanobacteria colonies imbedded in sandstone and show when geological areas were under water. They may have slowed stream flow, captured silt and started the process of filling in stream beds.

-Radioactivity can determine the age of rocks found in the layer of conglomerates. Though it may not be an exact science to determine the age of the rocks, it can be estimated by proximity to surrounding rock formations.

-Understanding past conditions (water energy, wind energy) may be better understood by reading cross sections of or profiles of a rock formation like the ones visited today.

-Wave patterns of the past may be better understood through profiling beach areas. Activities such as charting, graphing, identifying rocks in/on the beach, determining their elevation or relationship to the water will help us gain information about earth's ancient environments.

-Glacier movement, prior mountains locations and the direction in which the movements may have taken can be determined through the inspection and composition of alluvial fans.

In reflecting on his observations and experiences from the day's events, Ralph concluded his daily journal entry with the following statement about additional research of interest to him:

I would like to do some more research into the bed rock found in the water of the area we studied today. (There were striations and color differences that seemed to follow this rock formation that interested me). Though I asked about the gouges and color differences, no one really gave me a good answer

Nancy contemplated a different additional investigation as an outgrowth from the day's activities:

Perhaps we could date the rocks found in the different layers to determine the ages of the layers (when they were deposited).

Participant journals were collected and studied by the instructional staff each evening to monitor participant learning and to enable project staff to identify and subsequently address misconceptions that were surfaced and "further questions" that were posed. The instructional staff initiated a breakfast debriefing, focusing on the participants' journal queries and suggestions for further activities.

In addition to the field journal, the teacher participants provided ongoing daily diagnostic feedback on their "Daily Check-up Form," where they assessed their own grasp of the material presented during the day. When participants expressed doubt that they had mastered the concepts or had questions about what was presented during that day, the instructors were able to have the PI address the questions at breakfast or were able to modify the planned activities to better meet the needs of the participants. (See "Daily Check-up for Day 2" below).

During planning for the two-week field study, we had considered including an evening debriefing following dinner each night, but we were glad we had abandoned the idea. As Ruth indicated:

I was exhausted at the end of the day, not just from being outside, but mentally exhausted

Daily Check-up for Day 2

Written Summary of the Day's Activities in Field Journal

Problem statement – "What role do microbes play in forming geologic deposits? How can biological and sedimentological features in rocks tell us about Earth's ancient environments? How do we know how old rocks are? How does this very different, very ancient environment inform our current understanding of living on Earth?"

	Excellent	Satisfactory	Needs Improvement
Problem statement			
Claim			
Evidence: Related the data collected in this activity to the day's problem			
Reasoning: How does evidence support your claim?			
Future Research: If you had another day or week to study this problem what would you do next?			
List any unresolved questions you have			

Non-Graded
Review the "Anticipated Outcomes" listed below. For each outcome, please rate your understanding of the concept and its potential implications.

Benchmark of Day's Anticipated Outcomes - Please use a 1-5 numerical scale to rate your proficiency, with 1 being low (don't understand, low confidence in learned skill) and 5 being high (concept is well understood, confident that you can accurately use the skill)

As a result of the day's activities you may be able to do the following:	
2.1 Ability to make sketches of geologic features.	5 3 1
2.2 Ability to read rocks, especially sedimentary environments.	5 3 1
2.3 Ability to use a Brunton-type compass and hand lens.	5 3 1
2.4 Ability to take field notes.	5 3 1
2.5 Ability to identify transitions, or contacts between different rock units.	5 3 1
2.6 Ability to identify quartz, feldspar and other minerals in rocks.	5 3 1
2.7 Ability to identify sedimentary structures and trace fossils in sedimentary rocks.	5 3 1
2.8 Ability to interpret depositional environments from sedimentary rocks.	5 3 1
2.9 Ability to understand links in geologic and biologic systems.	5 3 1
2.10 Understand geological time, radioactive decay and geological age dates.	5 3 1

Overview of the rest of the project

The operational framework linking the strategies, activities, and desired outcomes of the second day of professional development to the over-arching question was essentially the same for the following two days in the Upper Peninsula and for the first two days in the Grand Rapids area. The locations, selected content, and over-arching questions focused on a variety of high-priority content topics, including Earth resources (copper deposits and mines in the Upper Peninsula and gypsum deposits and mines in the Lower Peninsula), water resources (Lake Superior, Lake Michigan, and the Grand River watershed in and around Grand Rapids), and aquatic, atmospheric, and terrestrial environmental effects related to mining and urban development.

On the final day in the Upper Peninsula and on the third and fourth days in the Lower Peninsula, the Grand Rapids Public Schools science consultant, who had been a participant in all the field activities, met with his teachers in a classroom to focus on classroom applications. He encouraged them to work together in linking the field experiences directly to the district-adopted *EarthComm* curriculum materials, and then to weave Disciplinary Literacy techniques throughout their emerging lessons.[3] Teachers worked in pairs in a modified "jigsaw" approach, adapting different lessons, then reconvening to the larger group for summaries and shared feedback. This lesson synthesis with pedagogical infusion was given a very positive assessment by the participants in their follow-up evaluations.

The last day of the workshop was designated "Leadership Day." The grant provides opportunities for participants from early cohorts to provide assistance during the formulation of activities for later cohorts, and it is anticipated that some of the participants will want to exercise leadership in other capacities. Accordingly, a decision was made to provide a formal leadership training day at the terminus of the two week workshop.

Evidence of Impact

The teachers kept a field journal that contained sketches, diagrams, notes, and data collected during their investigations along with a brief written summary of the day's activities using the *problem, claim, evidence, reasoning* format. The *reasoning* section was seen as particularly important, as it allowed the teachers to link the collected data and evidence to the problem posed at the beginning of the day. Each evening the teachers submitted their field journals and instructors reviewed the written field notes along with the written summary for the day's problem. The instructional staff provided written feedback (recorded in the field journals) to each participant on a daily basis, but did not assign grades to the field journals. The annotated field journals were returned at the beginning of the following day. The participants found the process

[3] The Grand Rapids Public School District has adopted the Disciplinary Literacy initiative created by the Institute for Learning at the University of Pittsburgh. The Disciplinary Literacy Framework states that for students to learn in science they must use science-specific habits of thinking to develop understanding of the conceptual content of science. Teachers must then be able to teach in this manner which requires content expertise – including both the conceptual knowledge and the habits of thinking/habits of practice in science. For example, one principles of the framework involves adhering in instruction to aspects of the nature of science such as claim-evidence-reasoning.

valuable, even if some of them objected to the feedback about a need to write "more scientifically." Said Ruth:

> *Journaling – hey I'll write the journal but I won't write like a scientist would write, what I wrote in my journal was me but I got a comment that I should write more scientifically. [Afterward] I was proud of my journal because I wrote like a scientist, so I liked it because it pushed me and it was a great way to learn and I would like to be that kind of a teacher for my kids at school.*

At the conclusion of each portion of the workshop (i.e., Week 1 in the Upper Peninsula, Week 2 in Grand Rapids), summative evaluation surveys were distributed to the teachers. The feedback they provided was to be used to evaluate the appropriateness and suitability of the activities and the effectiveness of the instructional staff. Additionally, the data acquired through the survey would be used to inform improvements in the future iterations of the summer program. Although many of the of suggested improvements were logistical in nature (e.g. more consideration paid to restroom breaks and adherence to the advertised lunch schedule), other feedback was related to the delivery of content, e.g., more/less emphasis/on particular topics, more effective use of travel time, modifications to the assignment format, and more substantial modeling of classroom ideas and activities related to the content. These survey results were "front and center" as preliminary planning efforts for the second year of field studies were initiated.

With the goal of evaluating the gain in teachers' utilization of inquiry methods, classroom observations were conducted in each participant's classroom prior to the start of the summer field studies by members of the project team who had been trained in the SAMPI lesson observation protocol. The first cohort of teachers will be observed using the same method following their completion of the three-year professional development cycle.

Lessons learned

Throughout the summer and on into the 2009-2010 school year, an earnest and conscious effort has been made to acquire participant input and feedback and to carefully consider implementation strategies to ameliorate identified deficiencies and miscues.

The collection and analysis of survey data and journal entries, as well as conversations with the teachers who comprised the first cohort of MiTEP, have provided key understandings of how the teachers were able to learn content, assimilate it into their classes, and grow professionally through the first year of the project. Based upon these data, some improvements have already been implemented and others are being planned. Taken together, the implemented and planned improvements can be summarized in three categories; *logistical, procedural, and pedagogical.*

Logistical improvements

Some participants indicated that the first day's activities were rushed and a bit disorganized and overwhelming, especially just at the beginning. In organizing for the second summer's professional development, the MiTEP project team is considering including an evening session at the beginning of the program to mitigate some of the first morning's tension.

A suggestion to add an after-dinner wrap-up of the day's activities continues to be debated. Some of the participants suggested this as an improvement, while others indicated that the day-long field study left them feeling exhausted. Furthermore, some participants had brought their families with them, and adding an evening session would have been problematic for them. This issue has not yet been resolved.

The surveys also emphasized building restroom stops into the daily plan. This suggestion is certainly valid, and it will be addressed in planning for the second summer's activities.

Procedural improvements
Clearer, more abundant and timely communication was widely recommended by the participants. Although the project's website included details related to each day's activities, the instructional staff was urged to reinforce the communication by providing alerts and details regarding destinations and attire. Additionally, some of the participants indicated that they did not feel adequately prepared to use some of the equipment included in the field study, and they encouraged the planners to initiate more extensive, hands-on guidance in using the scientific research tools provided. Both of these suggestions will be incorporated into the future plans.

Pedagogical improvements
The project planners were encouraged to provide concise articulation among the activities conducted in the field, the Michigan High School Content Expectations, and the EarthComm curriculum materials. The participants also indicated a need for additional classroom activities that would be similar to those experienced in the field. Work has already begun in this area; instructional have been meeting with Grand Rapid teachers to discuss issues related to articulation. In addition, a "Scientists on Call" has been established to facilitate a conduit for student and/or teacher questions, and we have created a series of video segments featuring Earth scientists responding to Grand Rapids student questions.

As noted earlier, three of the ten days during the summer were designated as "pedagogy days" and an additional day was devoted to "leadership." A plan to distribute the information included in these four days throughout the field studies is being considered for the subsequent iterations of the summer field studies.

The Project Team has also shared ideas about what we would do differently if we were starting over from scratch with a similar group of teachers.

First, we realize that it is critical that we understand the instructional culture of the K-12 partner institution. While it was logistically impossible for the members of the instructional staff to receive formal training in Disciplinary Literacy prior to the summer workshop, it was clear that had this been given more emphasis, the first few days of the workshop would have progressed much more smoothly.

Second, in an attempt to serve the maximum number of teachers, although our initial target audience was eighth grade teachers, applicants from other grade levels and other disciplines were accepted into the first cohort. While this decision assured a broader participant base, it also contributed to a certain degree of participant frustration. It has been posited that a smaller and more targeted group may have been better.

Third, although the nature of science was modeled throughout the professional development, explicit discussions of how teachers were developing science knowledge were not included in this first year. Similarly, explicit discussions about how to teach the disciplinary content that was the focus of the institute were confined to a few days led by the Grand Rapids science consultant. In subsequent years, this aspect of the professional development was expanded as teachers had daily assignments to develop strategies for addressing student misconceptions in the addressed content areas and developed a disciplinary literacy inquiry lesson that addressed one or more common misconception. Such discussions were also included in pedagogy/content workshops conducted by the graduate students four times during the academic year.

Fourth, a commitment outlined in the grant to affect institutional change at the university level by involving faculty from the partnering institutions as instructional contributors was largely delayed until the second year of the grant. Had more emphasis been placed on this commitment during the first year of MiTEP, a cadre of pedagogically- prepared university instructors would be ready to meet with both cohorts of Grand Rapids teachers. With two separate cohorts of teachers being served with two separate sets of field experiences during the upcoming second year of the project, the logistics of coordinating all of the activities while also initiating the university faculty in Disciplinary Literacy methods of instruction and district-specific content may be quite complicated.

Finally, with such a large number of contributing members from partner institutions that are separated by nearly a dozen travel hours, overcoming communication challenges would probably command a higher priority if we had an opportunity to begin anew. Of course, effective communication is likely a critical component of *any* MSP, regardless of the physical distance separating the partner institutions.

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