

GEOTEACH Assessment Executive Summary

by Tom Repine

Inquiry learning is philosophically rooted in dilemma. In other words, allowing the learner to work through, in their own way, a situation, can lead to enduring comprehension and the development of life long habits of learning. GEOTEACH participants quickly experienced this type of learning.

GEOTEACH participants considered themselves comfortable in their perceptions of geology and geologic field work. Nevertheless, the results of post-GEOTEACH administered instruments (Table 1) and reflections indicated they had just been through an astonishing experience. In their own words, it was a “big learning process...a struggle with long hours...physically demanding [with] moments of confusion and frustration. [There were many] things we had never done and never known about. We were jumping into something very deep and not knowing how to swim. [For example,] we had little or no idea of strike and dip. [After being] totally baffled at first, we had a lot of ah ha’s! [With each one we realized] we had come a long way. [In fact] we are really pleased with ourselves that we could figure things out.”

During the field sessions the participants had the chance to observe professional geologists measuring and recording observations. These observations formed the basis of a significant dilemma encountered during the participants early project work. The problem centered on their ideas of how geologic field work should be done versus how they saw professional geologists do field work. Specifically, participants initially assumed detailed rock descriptions were indispensable. Thus, their first attempts to describe an outcrop consumed all available time and energy because “we had to look at every rock in the outcrop. We wrote a novel of 26 pages on stuff the geologists used one page to describe. It was all the same to them but we kept looking for more detail” Gradually, participants began to understand that “geologists do not work like that. [We] had to get comfortable with that. Geologists are more comfortable making connections without data.” One participant stated: “Looking at the rocks smart allows geologists to put the big picture together. We were very concerned about detail and would write lots and lots. [They are] much more casual and comfortable saying a [thick] unit is the same.”

Adapting to this “big picture” skill accomplished three things. First, it reinforced the idea that terminology is a useful short hand because it allowed the geologist to say a lot with a few words. Secondly, the learning process shattered the participants’ “tunnel vision. We learned that [we] had to apply more of the big picture thing across the outcrop [because making a geologic map] is really all about the big picture.” Third, it allowed them to finally come to grips with the concept that a geologic map is nothing more than an graphical interpretation of accumulated and recorded observations. This was shown when a comparison of pre- and post-responses to open ended questions was conducted. (See Question 4, Appendix A.) According to one participant, the ability to use the big picture approach “changed my life about how geologic maps are made because I didn’t understand how it could be done with details.”

By the end of the participant’s first full week of field work (June 23 - 28) they became more accepting of our inquiry approach to learning how to do field work. More than anything else, they attributed this acceptance to cooperative team work: “talking within the group really helped to organize understanding...after some initial hesitancy [we] wanted to work with the team more than work

alone...[we just] had to get comfortable first.” Much of the uneasiness came from having to try things “we had never seen [and] had never heard about. [W]e were totally amazed!” As expected, trying to learn, and then use, new skills produced varying amounts of personal apprehension. But, as predicted by inquiry theory, it did produce the personal and professional growth demonstrated by the pre and post-GEOTEACH data. For example, several participants agreed when one said: “strike and dip was abstract before. [In RockCamp I] we wrote it down but had no clue what it meant. We were not sure what ‘dipping away’ really meant.” After GEOTEACH they stated they “felt really comfortable” with such terminology. This change is reflected in the large gains in the number of accurately used concepts between pre- and post-concept maps generated by each participant (Table 1 and Appendix B).

Some of the growth they experienced was attributed to “a lot of one on one” interaction with project staff. This referred to the personal training offered by the staff. It also was a reference to the “trickle down effect” it stimulated as ideas and skills mastered by one participant were efficiently transferred to others. For the most part, this flourished when other participants encountered a problem. Consequently, it is fair to state GEOTEACH participants were both learners and teachers. A good example of this was strike and dip and the brunton compass. Confusion with trying to explain strike and dip was effectively toppled as each participant shared with others how the brunton compass was used to measure strike and dip: “Some of us used [strike and dip] wrong for a day or more. [Once a few of us] were shown how to properly use it the word spread [and]it was much easier to actually work with the rocks.”

The team concept, as designed by the instructors, was discussed at length. Each team consisted of three teachers. This “was a perfect size. [Any] more and [we would have] been in each other’s way. [Any] less [and there would] not be enough to do everything.” Another value of the team approach was the fact that “it was really neat to be with like-minded learners with similar interests.” However, the team concept was not entirely problem free. A significant difference of opinion about the division of labor within the team was noted (Question 20, Appendix A). Post-GEOTEACH discussions revealed the staff’s idea of mandating that each team member do only one task each day was the core of the problem. The participants insisted “having each person have a job didn’t work.” In fact, it created problems. The concept became a much despised “stumbling block” which inhibited participant self-determination, made it difficult to learn and organize the work, and inadvertently reinforced misconceptions “when only a single voice with the most current understanding was heard. [Instead we should have] focused on a particular [skill] each day. For example, have everyone measure one day and everyone describe one day. This would help everyone learn needed skills instead of creating specialists.” Another stated, “I did not pay a bit of attention to measuring when I was writing. [As a result], I had no feel for other parts of the experience because I was concentrated on a single task—[that] needs to change.” Realizing this was detrimental, one group changed their procedure: “all three of us refused to follow instruction and took turns. We are adults and we know how we learn best.” As a result, the participants suggested that it would be more educationally appropriate if each person, each day, had to experience, learn, and do, each job. In their words, this would produce a “a real evolution of learning.”

Relationships between two of the project staff and GEOTEACH participants have existed for many years. These staff members have been present as these teachers progressed from introductory to

GEOTEACH sessions. When participants were asked if their previous RockCamp experiences been prepared them for GEOTEACH, they all agreed with the comment: “Yes. It now makes sense and has more meaning. Little pockets of knowledge were pulled together finally.” However, a more revealing comment on their professional and personal growth was the following declaration: “It was good Tom and Deb were not at GEOTEACH. That made us challenge ourselves more. You took care of us better than Dave did. But, we are now ready to not be taken care of. [We] have moved along and can work on our own. [We] would not have been comfortable [doing that] without previous a RockCamp background.”

GEOTEACH’s most prevalent accomplishment was its ability to let teachers actually be a scientist. This was constantly mentioned in the participant’s post-session comments. They “really have a strong feeling that teachers should do real science.” Another stated that the best way to learn how to do geology and how to make a map was to be “out there on those rocks [because] it was the real thing. [It is] very valuable being a real scientist for a while were we do not know the answers.” Based on their comments, it may be suggested that this goes beyond personal growth and satisfaction. It centers on their professional compulsion to transfer, in some way, what they have learned into their classrooms. Thus, while the project was not specifically designed to directly impact students, the participants are keenly aware of an internal need to do this. They recognize that “the intangible thing of [actually] doing real science carries over into teaching.” When pressed to provide examples, they claimed it is “hard to identify direct activities” from GEOTEACH. More importantly, to them, the experience “makes you more credible with students because they now you did the real thing. It makes you a more creditable source because you like science and demonstrate that by doing it.” Another participant suggested this type of experience was “really helpful when working with a only one or even a few students.” She explained her opinion by saying: “Explaining a geologic map to students? I now understand how it was made. Students often ask ‘How do they know?’ I can answer that now because I was an experimenter!” Another participant added the experience would be extremely useful when “helping with science fair projects.” Yet another noted, and the others then agreed, the experience had placed them in the role of the “confused learner. I have been the student now and [I] understand their confusion.”

Although they become more accepting of GEOTEACH’s “radical inquiry approach,” there were moments when this outcome was in doubt. Early on, the staff was aware of the participant’s frustration. After all, these teachers were experiencing something totally new. They “had no idea how to begin making a map.” They all admitted “we always felt there was not enough data because we didn’t know about interpreting data.” While this was to be expected, it was not always a pleasant thing to watch. A good example of annoyance was revealed as different perceptions and interpretations of a single outcrop were discussed by the staff. As a result, we made a concentrated effort to explore the issue of participant frustration using post-session instruments (Table 2, Questions 18 and 19) and interviews. After their initial shock, frustration, although mentally unpleasant, did not evolve into a problem. However, the participants were quick to point out a difference between frustration and anxiety. Frustration was an emotion encountered when working through a dilemma. It became part and parcel of the experience once they realized “frustration levels must change” as experience and understanding grows. However, if noticeable change did not occur, anxiety, described as “a general,

debilitating feeling,” would take over. Thus, for our participants, frustration, which every professional geologist deals with, was accepted, within limits, as part of the learning process. Some participants kept frustration from turning into anxiety by interacting closely with the staff. For others, “it was vitally important [the staff] offer ways to deal with it.” Some dealt with it by making it into a contest. By looking for opportunities to confront the staff “we found things the geologists did not understand or know. The revelation that they were, and might remain, unknowns helped us deal with [our frustration]. We didn’t feel so bad. [It was OK] to disagree.”

As a result of their experience, the participants believe “we can now help in the future by playing the role of offering better instruction.” While this at first seemed to be a positive judgment of newly-acquired mentoring abilities, such was not the case. In fact, this comment generated a participant debate over the merits of GEOTEACH’s pedagogical methods. The split centered around some participants perception of a “lack of instruction.” While post-GEOTEACH Lickert results (Table 2, Question 16) indicate general acceptance of the received instruction, reflections and interview data reveal another story. Many individuals suggested “a better way to set up the instruction [was needed].” Continually having to ask questions, was, to a few, “belittling. [It would have been] more efficient to have objectives and goals and [to offer] instruction to the whole group at one time.” Some commented “we needed to see a [geologic] map to see what it looks like before doing our own. [We] need to know how maps are made [before making ours], the rules for map making needed to be set forth.” In essence, for them, there was “too much inquiry. [We] needed some direction.”

It is suggested that these differing opinions can be attributed to the individualistic nature of human learning and the participant’s prior experiences with more traditional teaching and learning methods. Nevertheless, not everyone bought into the argument that this is the best way to learn how to make a geologic map. Slightly less than half of the group remained adamant in their desire for more traditional instruction. Comments such as: “We needed more rock description work in the first week...How can we do this if we don’t have the intuitive sense to know what is there?...I needed to know what to look for...[and] we needed more section descriptions beforehand to help us in the field” reveal the ingrained nature of the traditional style of learning. Nevertheless, a majority of the participants endorsed GEOTEACH’s inquiry approach. Their opinions were best expressed when one stated “if we do get more [concrete instruction] we are removing a critical element from the experience. [I] learned this is the most important part [of the experience.] You wanted us to figure it out. It worked.” These participants became aware of the “fine line between instruction versus what we are doing and how to do it.”

In the end, the group consensus was that, having been through the experience, they should have more say and influence on the “design stage [of GEOTEACH]. As teachers we have the ability to help the [staff] organize how to present the material.” A specific example of this were staff requirements that an outcrop be measured in a certain amount of time. As a result, “we felt we had to reach certain goals and worked to that when describing a section.” One participant claimed this “overwhelmed my ability to learn.” Another suggested this contradicted the program’s stated inquiry-approach “because it put pressure on us to meet objectives.” To rectify this problem, the participants suggest the staff “reevaluate how much section can be done in a day by the teachers.”

Suggestions for improvement included moving the first two introductory days nearer to the area where the work would be actually be accomplished (i.e., “the first week needed to be in the valley and ridge”), providing “some sort of glossary to help with terms,” and “being real up front about the physical nature of the work for the next group...not everyone who has been to RockCamp could do this.” Interesting comments on the tools chosen for the field work were also made. A traditional method of measuring the thickness of rock units is the Jacob’s staff. Much of the first three days of the experience were spent making and introducing teachers to this device. In the end, comments such as “too much Jacobs staff, we never used them” questioned the value of this effort. The Brunton Compass was also used to measure sedimentary rock strata. Unlike the Jacob’s staff, this device became the participant’s most useful, and enjoyable, tool. It was amusing to see how rapidly the teachers accepted and used the relatively complex Brunton Compass as compared to simplistic Jacob’s Staff.

As the final post-session group interview drew to a close the participants began to reflect on the meaning and value of the experience. After the obligatory “best I have had in 10 years” and “it was good” comments, three important opinions were revealed. First, the experience had allowed them to “do real science.” This was best expressed in comments such as “I experienced the different ways geologists are trained and do field work” and “I feel this has been a real science experience.” In this context, it also provided them a chance to experience the messy side of geology because “we had no one to ask, so we had to learn to make decisions and trust yourself. It was nice to be turned loose.”

The second value of GEOTEACH was an eagerness to put newly learned skills to the test. Even though it had been an “intensive experience...we’re ready for next phase in a unknown area.” The idea of working an unknown area captivated quite a few of the group. To the staff, the concept of an “unknown geologic area” in West Virginia was difficult to fathom. Geologists have been working here for more than 150 years. However, with discussion, clarification between staff and participant perceptions was obtained. The participants were suggesting an area which they had never been to before. They reminded the staff they had been to the GEOTEACH mapping site on a previous RockCamp field trip. As a result, their prior knowledge of the location came into play. While sometimes helpful, it was ultimately detrimental when they discovered that interpretations ingrained during their previous visits were, by the GEOTEACH staff, regarded as fundamentally flawed. As a result, participants ran into the early, and frequent, problem of reconciling misconceptions with their own observations. From the staff perspective, this was not necessarily a bad thing because it did demonstrate how science works and invited participants to develop methods for arguing the merits of alternate ideas. Nevertheless, it created the frustration.

Fifty percent of the participants suggested future participants “need to go work an unknown area to us.”

The third aspect of GEOTEACH relates to appreciation of geologic field work. Pre-test responses indicate a good understanding of most geologic ideas and concepts. In fact, the best way to summarize the pre-test responses is to suggest they reflect participant’s philosophical, preconceived notions, and prior learning of maps. After GEOTEACH, all of the participants agreed their personal perception of geologic field work had “evolved into something more realistic.” Post-test responses (Appendix A) and concept maps (Appendix B) reveal a more frequent, and accurate use, of process and skill terminology. Thus, a positive change in perception of what field work is and how it is done is suggested.

GEOTEACH's ultimate aspiration was to alter teachers' perceptions of a geologic map. The assumption was, while a teacher might easily define a geologic map, as a user they did not fully understand what the map represents nor how it was constructed. Consequently, the teacher's students would not fully appreciate the science behind a geologic map and the map's potential relevancy. To judge if any change had occurred in the participants' views pre- and post-assessment, an instrument asked them to define a geologic map. Significant change in pre- and post-responses to this question were not profound. One interpretation of this is that participants' prior RockCamp experiences provided them a solid foundation in the concept of a geologic map.

More likely, a truer interpretation of GEOTEACH's impact upon participant perception of geologic mapping and a geologic map is revealed when they were asked to react to the following statement (Question 4, Appendix A): "When a geologist collects information in the field about the stratigraphy of an area s/he can construct a map which is a true representation of the rock units of that region." In general, the responses demonstrate the skills, knowledge, labor, and tenacity of the field geologist, in their effort to construct a geologic map, are more clearly respected than before GEOTEACH. More importantly, from a professional development point of view, the participants seem to now clearly understand that a geologic map is an interpretation. Thus, it is suggested that GEOTEACH, as has no other RockCamp-related event, has revealed to its participants the true interpretive nature of science (in general) and geology (specifically). It has clearly provided the participants with the opportunity to come to understand on their own terms. And, it has accomplished this by letting them do science:

Based on the work that I did this summer I feel that a portion of map construction, while based on sound collected data, involves plain old educated guessing. At Greenland Gap, we...sampled areas and identified rocks, we identified contacts between strata, we had a knowledge of the geologic history of Greenland Gap, etc. But, putting these individual points together in a cohesive overall geologic "layout" involved some good solid guessing! "True representation" are words that don't really seem to fit that which is not readily visible. Extrapolation [and] interpolation are terms that applied to what we did and are not part of "true representation."

The result of a mix of inquiry-based pedagogy and geological investigation must be addressed. Did GEOTEACH provide its participants with anything that can be implemented in their classrooms? On one hand, the program provided them with skills and some tools. More importantly, to those of us in the earth science education community, the GEOTEACH experience appears to have altered some of its participants' views on the nature of science. This will be an indirect, but significant, contribution to the way they teach science in their classrooms. This opinion is best stated by one of the participants:

It is hard to imagine any geologist who would attempt to map an area without spending lots of time and effort in gathering field data. First of all that seems to be their first true love—the #1 reason they are working in geology. Also seeing and feeling (even smelling) the rocks is essential to understanding the dynamics behind the stratigraphy. No scientist should ever

rely blindly on the data gathered by others, and I don't believe I've ever met a geologist who would even consider doing that. Ah, the implications for the science teacher! How often do we expect our students to rely on data recorded by others? To blindly accept what the text and/or the teacher say as true without independent confirmation? How many potentially great geologists and other scientists are turned away from science by the quantity of facts to be memorized (even if they are not understood) and a lack of opportunity to practice science as a process?

As part of their involvement, GEOTEACH participants were asked to share what they had experienced. Their ideas for professional outreach took two different forms. The first was a formal talk. They produced a PowerPoint presentation for an audience of professional geologists. An abstract of the talk was accepted and published by the Geological Society of America. Serving as a representative, one of the GEOTEACH participants described the program to an audience of 63 professional scientists. Their second idea was to promote local professional development for peers. GEOTEACH participants proposed and conducted two sessions at the 2002 meeting of the West Virginia Science Teachers Association. These sessions drew about 20 teachers. In their home areas, participants decided to offer peers professional development opportunities sanctioned by local schools. As of the date of this report, three two-hour workshops and one four-hour field trip have been offered by five GEOTEACH participants for 23 local teachers (11 middle and 12 high school) in Pocahontas, Pendleton, and Randolph Counties.

As a concluding thought, it is important to remember these teachers are not geology majors. As a result, learning how to do field work by doing field work could have been mental and physically intimidating. In the end, GEOTEACH provided these teachers the chance to develop, mostly on their own terms, the skills most needed by all scientists: a belief in one's own abilities, the ability to work with others, and the ability to learn the difference between guessing and interpolating. These are the useful attributes of the field geologist. Thus, what the GEOTEACH participants experienced quite accurately mirrored the situation new geologists encounter when they first tried to actually "do geology."

Participant	PRE	POST	CHANGE	PRE	POST	CHANGE	PRE	POST	CHANGE	PRE	POST	CHANGE	Percentage gain in accurately used concepts
	Hierarchical levels other than domain	Hierarchical levels other than domain		Described links	Described links		Number of level two concepts	Number of level two concepts		Number of accurately concepts used	Number of accurately concepts used		
Ann	3	5	2	0	0	0	3	3	0	7	16	9	229%
Chris	1	4	3	0	0	0	1	4	3	6	30	24	500%
Julia	1	3	2	0	0	0	5	5	0	6	30	24	500%
Karen	0	7	7	0	0	0	1	3	2	10	22	12	220%
Kathy	0	3	3	0	0	0	0	3	3	6	26	20	433%
Paula	4	3	-1	6	20	14	1	4	3	14	19	5	136%
Sheba	2	5	3	0	0	0	1	1	0	6	13	7	217%
Mean	1.6	4.3	2.7	0.9	2.9	2.0	1.7	3.3	1.6	7.9	22.3	14.4	319%
Median	1	4	3	0	0	0	1	3	2	6	22	12	229%
Mode	1	3	3	0	0	0	1	3	0	6	30	24	500%

Table 1. Comparison of selected characteristics of pre- and post-experience participant concept maps.

Question	Mean (4 = strongly agree, 1 = strongly disagree)	Standard Deviation From Mean
1. This experience is beneficial to teachers.	4.00	0.00
2. This program is useful for classroom teachers.	3.75	0.46
3. The program was successful is exposing me to geology field work.	4.00	0.00
4. This program gave me a better understanding of how geologic mapping is done.	4.00	0.00
5. I am intimidated by the professional geologists.	1.13	0.35
6. Field techniques taught during this program could be taught to other classroom teachers.	3.88	0.35
7. Some of these field techniques could be taught to students.	3.50	0.53
8. My expectations were met by this program.	4.00	0.00
9. The program needs considerable improvement before being implemented again.	1.50	0.53
10. I enjoy doing field work and research.	4.00	0.00
11. If given the opportunity I would participate in another field based program.	4.00	0.00
12. The staff was helpful in achieving our goals.	4.00	0.00
13. I have a better understanding of geology concepts after attending this experience.	4.00	0.00
14. Projects were reviewed and returned in a timely manner.	3.50	0.76
15. Journaling is not worthwhile.	1.75	0.89
16. The instruction provided during this experience was adequate.	3.63	0.52
17. Seeing models of each of the products before doing them would have been more helpful.	3.13	0.64
18. The experience was overwhelming or debilitating.	1.25	0.71
19. The experience was frustrating.	2.50	0.76
20. Assuming a different role each day in groups was a good way to learn skills.	2.00	1.07
21. We should follow up his experience by applying our skills to an unknown area.	3.75	0.46

Table 2. GEOTEACH Lickert Instrument Final Evaluation Summary