Panama GABI RET
5-Year Summative Evaluation Report

Prepared for
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"This program has changed my life for the better. Not just for my career, but the networking and relationships forged through this program remind me that there are warriors out there (K-12 teachers) that are fighting for new generations." (GABIE RET Year 4 Scientist)

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I. Introduction

This report presents the summative evaluation findings of a five-year project including the PCP PIRE Teach (2012 to 2013) and the Great American Biotic Interchange Research Experience for Teachers (GABI RET; 2014 to 2016) projects. These were funded by the National Science Foundation (NSF), to the University of Florida (Florida Museum of Natural History) that sought to provide field-based professional development for STEM teachers. This professional development had several goals, including to provide:

- authentic field experiences along with scientists
- scientific content to be translated into the classroom
- research and co-publication opportunities
- a space for educators and scientists to collaborate

This overall project is an outcome of three NSF funded grants, including:
(1) two supplements funded in 2012 (1237203) and 2013 (1321453) to the PCP PIRE (Panama Canal Project: Partnerships for International Research and Education - 0966884), referred to as PCP PIRE Teach; and
(2) the GABI RET (1358919).

During cohort year one (2012), five educators from Santa Cruz, CA went to Panama to work on the research project. Teachers and administrators not only liked what they experienced, but they also thought that exposing teachers to these type of international field experiences was extremely valuable for classroom instruction. In cohort year two (2013), there were six new educators (five from CA and one from FL). During the fall of 2013, in collaboration with teachers, scientists and K12 administrators, the GABI RET proposal was submitted to NSF. The proposal was funded in February, 2014, and has involved an additional 36 educators. The project is still engaging 47 of those educators.

For convenience, in the remainder of this report, this overall project will be referred to as "GABI RET." Unless otherwise indicated, this will collectively refer to all five years (rather than just the last three years that were specifically funded from grant 1358919).

Scientific Background
The Great American Biotic Interchange (GABI) was catalyzed by the formation of the Isthmus of Panama during the Neogene. The GABI had a profound effect on the evolution and geography of terrestrial organisms throughout the Americas and marine organisms globally. For example, more than 100 genera of terrestrial mammals dispersed between the Americas, and numerous marine organisms had their interoceanic distributions cut in half by the formation of the Isthmus. The GABI is widely considered to have been a grand natural experiment documented by the fossil record. In addition to biotic effects, the formation of the Isthmus also affected oceanic circulation, global climates, and possibly triggered the Ice Ages during the Pleistocene.

Over the past several years, new discoveries have dramatically impacted our scientific understanding of the GABI. Until recently, the paradigm depicted final closure of the Isthmus during the Pliocene about 4 million years ago, and the dispersal of land mammals north and south commencing thereafter. However, this traditional scenario is being challenged by new fossil discoveries. Thus, rather than being considered a single event that occurred about 4 million years ago, the GABI likely represents a series of dispersals over the past 10 million years, some of which occurred before full closure of the Isthmus. New fossil discoveries in Panama resulting from the GABI RET are thus contributing to the understanding of the complexity and timing of the GABI during the Neogene.

This three-year project primarily focuses on professional research experiences for middle and high school STEM teachers, in diverse fields including biology, chemistry, earth and environmental sciences, and oceanography. Each year 10 teachers and three to five professional paleontologists participated in a four-phase process of professional development, including: (1) a pre-trip orientation (May); (2) 12 days in Panama in July collecting fossils from previously reported, as well as newly discovered, sites; (3) a post-trip on-line (cyber enabled) Community of Practice; and (4) a final wrap-up at the end of each cohort (December). In addition, some of the teachers also elected to partner with scientists in their research laboratories, principally located in California, Florida, and New Mexico. The in-country partners were from the Universidad Autonoma de Chiriqui (UNACHI), including faculty and students, as well as STEM teachers from several schools in Panama.

Deliverables of the GABI RET experience included the development of lesson plans related to fossils, paleontology, evolution, geology, past climate change, and related content aligned with current STEM standards (e.g., NGSS). The teachers engaged in the process of scientific discovery and participated in the development of research and then followed-up sharing their experiences via the on-line GABI RET Community of Practice. Dissemination of the GABI RET results occurred via papers presented at professional meetings and published in peer-reviewed journals, as well as those presented in popular media. Broader impacts of the GABI project include mutual collaboration for teachers and scientists, international and multicultural research experiences, broadening representation of participants and stakeholders, and sharing resources via social media and the web.

Summative Evaluation

This summative evaluation was commissioned in the fall of 2016 to collect data on the effects of the experience. This evaluation used multiple methods to collect evidence about the effects of the experience on the teachers, mentors and research over the grant's period of performance. This included; (1) All teachers who had participated were contacted for information (47 contacted, 42 responded; response rate of 89%), their lessons were analyzed for evidence of effects (22 lessons as of the writing of this report and growing), (2) a survey sent to the scientist mentors (N = xx, 15 responded in time for this report; response rate of xx%). In addition focus groups and other evaluation tools were implemented with teachers (N=22) and scientists (N=9) attending the final face-to-face summit at Ghost Ranch, New Mexico in July, 2017.

Summary of Findings

Sharing and Collaborations

The educators attending the summit (N=22) were asked to indicate the number of the different audiences they shared resources with since participating in GABI RET.

- The 22 educators reported they had directly reached a total of nearly 7000 people directly (112 administrators, 468 educators, 5050 students, 1087 parents, 232 public).
- Teachers estimated they had indirectly reached an additional 10,000+ people through media coverage.

Thirty-five GABI RET educators completed the Teacher Experience Survey

- A little more than a quarter of these teachers (29%) reported having presented information about their experience at a professional conference. The specific conferences reported were ISTE (12%) and NSTA (2%).
- About two-thirds of the teachers (66%) are continuing to collaborate with the scientists who acted as guides and mentors.
- The GABI RET website has a listing of all of the participants from each year, lesson plans and projects they developed, resources, contact information for project leads, and a listing of past and present events.
- The GABI RET Facebook page currently has 386 followers and 397 page "likes." Through the Facebook pages, the GABI RET team has reached over 1500 people in 46 different countries, and 19 different languages. Over an average month, postings to the page reach an average of 156 people ranging from as few as 43 to as many as 489.

Effects on Teacher Practice

A total of 42/47 educators contacted completed the Teacher Practice and Effects Survey. This teacher population was largely non-Hispanic (93%), white (86%), and female (79%). They had a wide range of teaching experience from early-career teachers (1-4 years– 9%), mid-career teachers (5-15 years– 53%) and longer career (16-30+ years– 38%). This group taught mostly 5-8 (50%) and 9-12 (43%). These teachers currently teach a variety of different subjects including biology (45%), earth science (35%), general science (26%). A majority of the teachers had participated in other field experiences (71%).

- The majority of teachers (81%) reported taking what they learned from their field experience and translating it into designing and redesigning classroom lessons and developing hands-on lessons and activities (57%).
- An analysis of 22 lesson plans presented at the summit showed: 1) Teachers were able to integrate the scientific content of their RET experience into their curricula, 2) The authentic field experience gave them a way to engage students in research practices, provide a real-world context for classroom work from their own experience, and to have credibility as researchers with their students, 3) Teachers demonstrated and reported being more knowledgeable about paleontology content, methods, and careers to share with their students.
- Teachers reported changes in their understanding of the content and increased confidence (43%), greater interest and engagement of their students (38%), and the value of parents seeing their students being excited about their learning and classroom projects (15%).
- Thirty-five teachers completed a content knowledge test, which supported the self-report data by the teachers that they learned new content.
- More than half of the teachers reported engaging their students in a number of activities associated with 21st century skills (Partnership for 21st Century Skills, 2008) in the classroom at least half the time with 100% of the teachers using at least one skill set in each class period.

- Project teachers were overwhelmingly in agreement about the importance of offering students challenging learning opportunities. All of the teachers (100%) agreed or strongly agreed that it was important to have students lead others to accomplish goals, encourage others to do their best, produce high quality work, respect the differences of their peers, help their peers, include others' perspectives when making decisions, make changes when things do not go as planned, and to manage their time wisely when working on their own.
- The teachers rated the development of social and professional relationships with peers and scientists highest (8.9/10) followed by learning how paleontologists think and reason (8.5), developing ways to translate field experience into classroom activities (8.5), developing proficiency in field skills (8.4), and utilizing field experiences to develop lessons and lesson plans (8.4).
- When asked about their knowledge relating to STEM careers, the teachers reported significant changes in their knowledge of STEM careers (3.4/5 pre, 4.7/5 post), where to go to learn more about STEM careers (3.4, 4.5), where to find resources for teaching students about STEM careers (3.2, 4.5), and where to direct students or parents to find information about STEM careers (3.0, 4.1).
- The teachers had a mean pre-score of 54.3 on the Personal Science Teaching Efficacy Belief (PSTE) section of the STEBI (min=27, max=65, SD=8.5) and a significantly different ($p \leq 0.01$) mean post score of 60.4 (min=55, max=65, SD=3.7). The teachers had a mean pre-score of 38.4 on the Science Teaching Outcome Expectancy (STOE) section (min=30, max=46, SD=4.6) and a significantly different ($p \leq 0.01$) mean post score of 42.8 (min=31, max=55, SD=4.8). These scores are in line with or higher than what other studies have reported for post experience teachers mean scores (ESI, 2014; Holden, et al., 2011; Savage, 2004). These high post experience scores reveal a high self-efficacy among the program teachers after their GABI RET experience that they attribute to their research experience.
- The teachers drew directly from their field experiences to develop classroom practices to be used with their students, as embedded practice, and as part of their lessons. The field experiences can be divided into four areas: (1) Field Work, (2) Paleo-Talks, (3) Articles/Papers, and (4) Tupper Seminars. From each of these areas, the teachers developed translated what they had learned into meaningful practices in their teaching. For example, a type of field work was collecting and assembling kits. One teacher wrote about turning this into a best practice in her classroom where the students were responsible for gathering all of the necessary laboratory equipment for their work. Other teachers wrote about the content they learned as part of the Paleo-Talks they heard while in Panama. They translated what they learned into lessons for their students designed to help them better understand the complex nature of the GABI.

A total of 35/47 GABI RET participating teachers completed the GABI Teacher Experience Survey.

- A majority of the teachers (81%) reported that the signed-up for the program because they saw it as a learning opportunity and a chance to gain content knowledge and because they wanted a real-world/authentic science experience (57%). The same percentage (81%) hoped to build their personal and professional knowledge and develop ways to engage their students (57%), and found the hands-on opportunities, learning in the field, and working alongside scientists helped them meet their objectives.

- When asked how immersion in fieldwork as a result of being a GABI RET teacher evolved their classroom practice to engage students in the scientific process, all of the teachers were able to give at least one example of how they had used their field experience to engage students. All of the teachers (100%) described at least one way there were implementing the scientific process into their lesson planning and teaching, such as:
  - *The experience of GABI RET offered an opportunity to re-engage in the practice of science. This translated into more authentic experiences for my students in the scientific process.*
  - *This experience has pushed me to think more about engaging phenomena as an introduction to scientific discovery. It has also led me to focus on questions and science practices. We start with a 'hook' or a problem that students need to solve. Students have been excited about trying to conduct experiments, collect data, and talk about how they can find solutions to explain our phenomena.*
- The 35 teachers completing the Teacher Experience Survey reported developing and implementing a total of 141 lesson plans averaging four per teacher with a minimum of one and a maximum of 17.
- When asked to describe the specific content of the lesson plans they developed, the teachers named a wide variety of lessons including those covering the GABI (23%), the Gatun Formation (20%), horse tooth and evolution (20%), Megalodon jaw reconstruction (11%), and Megalodon total body length (11%).
- Project teachers were overwhelmingly in agreement on the importance of offering students challenging learning opportunities. They reported significant changes in all areas pre/post GABI experience including helping students to work with others to accomplish a goal (4.3/5 pre, 4.6/5 post), producing high quality work (4.5, 4.9), and including others' perspectives when making decisions (4.4, 4.7).
- A scoring rubric was developed and used by two of the project staff to score the anonymous teacher responses independently. Scored responses were compared across items and for overall score. After analyzing the overall scores, we found a discrepancy between scores for one of the eight items. Through discussion, it was determined that the item was not a good question. Based on the teacher responses and the range of responses given the question was not clear. The item was not used here and will be revised for future use.

The 22 teachers at the summit also created Causal Chains (Davis, Scalice, 2014) about their experience with GABI RET. A causal chain is a tool originally used in action research and has been adapted to help show the connections from beginning need through to outcomes from the experience.

- A majority of the teachers (81%) reported that they signed-up for the program because they saw it as a learning opportunity and a chance to gain content knowledge and because they wanted a real-world/authentic science experience (57%).
- The same percentage (81%) hoped to build their personal and professional knowledge and develop ways to engage their students (57%) and found the hands-on opportunities, learning in the field, and working alongside scientists helped them meet their objectives.

- The majority of teachers (81%) reported taking what they learned from their field experience and translating it into designing and redesigning classroom lessons and developing hands-on lessons and activities (57%).
- Teachers saw changes in their understanding of the content and increased confidence (43%), greater interest and engagement of their students (38%), and the value of parents seeing their students being excited about their learning and classroom projects (15%).

Effects on Scientists

A total of 15 scientist mentors completed the mentor survey in time for this analysis. Seven mentors were professionals in paleontology and eight were graduate students in the fields of geology, paleontology, biology and environmental science. Nine attended the summit and participated in focus groups.

- All of the scientists reported that working with the teachers changed their understanding of teaching and learning. The scientists wrote about learning about developing lesson plans and incorporating standards, how to make learning fun and engaging, the importance of classroom management, and the opportunities for learning. The scientists also wrote about enjoying the excitement the teachers brought with them into the field.
- 11 of the 15 mentors (73%) had an opportunity to visit a classroom – in-person or virtually. Most of those mentors visited more than one classroom or on class multiple times with one scientist visiting nearly all of the teachers' classrooms at some point. For the scientists that had the opportunity to visit a classroom more than once, they reported that, over time, they became more comfortable working with the students, were able to better communicate their ideas and answer the students' questions. For one mentor, the numerous classroom visits actually changed his intended career direction from researched focused to education: *"After the first few classroom visits, I became far more interested in science education that I was before and that led to my decision to pursue a PhD to merge scientific research with science education/outreach."*
- Working with the teachers as part of the GABI RET project had a strong impact on the scientists' own practice. The scientists felt they learned as much from the teachers as the teachers were learning from them. Their perception of mentoring changed from seeing it a one directional relationship to a two-way relationship where both parties benefit.
- Scientists reported significant increases in all areas: working with and mentoring teachers benefitted the scientists as science professionals (3.5/5 pre, 4.5/5 post), as educators (4.0, 4.9), and as individuals (4.0, 4.9), it is a benefit to teachers to have a scientist as a mentor (3.9, 4.7), and that they are better able to communicate science concepts simply and effectively (3.5, 4.5).
- The 15 scientists reported having a total of 177 continued collaborations with the teachers involved in the project (an average of over 10 for each scientist). Two of the scientists were only onsite for the field work and did not follow up classroom visits. One of the scientists reported having over 50 collaborations.
- The scientists strongly agreed that working with and mentoring teachers as part of this research experience enabled them to see how they benefited from the interactions (4.7/5), that they benefited from working with and mentoring teachers as part of this research experience (4.7), that their experiences in working with and mentoring teachers as part of the Panama project were positive (4.9), that working with and mentoring teachers changed their views about the demands and needs of K-12 teachers (4.7), that they would

like to work with and mentor K-12 teachers in the future (4.8), and that they felt it is important for students to have inquiry-based learning opportunities (4.7).

Professional Outcomes

- This project resulted in 10 papers published or submitted and awaiting publication to peer-reviewed journals, numerous presentations at national meetings and more than 140 lesson plans in diverse fields of biology, geology, ocean and environmental science. Results of our summative evaluation indicate significant benefit accrued back to the scientist/mentors; this observation had previously been reported in the literature (Tanner 2000), but not backed up by a validated instrument as we did. We plan to publish these results in an earth science education journal. The primary research products that are available include about 1,000 fossils catalogued in our research collections and available on-line; these also serve to enhance the NSF-funded iDigBio collection (Page et al. 2015).

Recommendations for Future Experiences

- Twenty-two educators and nine scientists participated in the summit at the Ghost Ranch in Abiquiu, New Mexico.
- During the summit, educators and scientists engaged in focus groups, completed surveys, presented their lesson plans, worked in groups large and small, hiked, and went on a fossil dig.
- Both educators and mentors attending the summit were asked to contribute their best ideas for the next iteration of the GABI program. Working in teams of three or four, the teachers and mentors discussed their ideas and then reported out to the rest of the group. They recommended that work with scientists in the field, cataloging, and other aspects be included in any future RET. They felt that this was critical to developing the teachers' passion for the science and to be able to effectively engage students in scientific practices. The educators wanted more time to develop lesson ideas when they were with the scientists. The scientists wanted more preparation of the teachers ahead of the field work, and more follow up afterwards.

II. Methods and Measures

A. Design

In this summative evaluation, we employed a mixed-methods approach (NSF, 1997; Frechtling, 2010) to collect quantitative and qualitative data. The evaluation examined educator and mentor participation throughout the project life cycle (Davis & Scalice, 2014; Rodriguez- Campos & Rincones-Gomez, 2013, Clarke et al., 2006). Both qualitative and quantitative data were collected from the teachers and scientist mentors. Quantitative data was summarized with descriptive statistics. Qualitative responses were analyzed using discourse analysis methods to identify themes (Johnstone, 2002; Schiffrin, Tannen, and Hamilton, 2001).

Evaluation Design
The evaluation plan includes a summative evaluation to document the impact of the three-year project and a research plan to examine how and why the project has impacted teachers and scientists.

Summative Evaluation Questions: *What was the impact on teachers? On scientists/mentors?*
Research Question: *How and why did the project have impact on teachers and scientists?*

Summative Evaluation Question: *What was the impact on teachers? On scientists/mentors?*
The tables below show the outcomes and the data sources used to collect evidence on the extent to which these outcomes were achieved.

We asked all 47 participants still in touch with the project to complete the surveys. We anticipated that 24-30 teachers and at least 12 mentors would participate. We received 42 teacher responses for the Teaches Practice and Effects Survey and 35 responses for the Teacher Experience Survey. We received 15 mentor responses to the Mentor Survey. All 22 teachers at the 2017 reunion participated in the focus groups, presented lessons, and created Causal Chains to characterize their participation in the project.

Description of Measures

Measures - Educators	**Description**
Lesson Plans	From presentations at July 2017 summit, N=22
Causal Chains	Completed at July 2017 summit, N=22
Focus Groups	Conducted at July 2017 summit, N=22
Teacher Practice and Effects Survey	42 Teachers completed the survey in April 2017 (included STEBI-A and Teacher Efficacy and Attitudes Toward STEM Survey from Friday Institute)
Teacher Knowledge and Experience Survey	35 Teachers completed the survey in April 2017

Measures – Scientist	**Description**
Mentor Survey	Developed, refined, tested and utilized with 15 mentors in May and June 2017
Focus Groups	Conducted at the July 2017 summit, N=7

Teacher Development

Expected Outcomes	***Data Sources***
Increased STEM knowledge related to GABI research focus	Teacher understanding of fundamental research questions for GABI research (test on 5 questions scored by project staff)
Increased understanding of scientific practices	Analysis of lesson plans for incorporation of scientific practices Retrospective survey questions on understanding and use
Increased awareness of STEM careers	Use in lesson plans General methods of incorporating careers Survey items on career introduction
Increased networking with other	Website community of practice analysis to include sense of

teachers and scientists	community, knowledge development, and value creation

Teacher Practice

Expected Outcomes	*Data Sources*
Increased confidence in teaching the research process	Analysis of lesson plans for incorporation of research process STEBI-A
Increased use of inquiry science in the classroom	Retrospective survey questions on frequency of use of inquiry STEBI-A
Increased enthusiasm for teaching science	Teacher Efficacy and Attitudes Toward STEM Survey by Friday Institute

Scientists/Mentors

The data sources for effects on the scientist mentors were a self-report survey and focus groups on the effects of their research, their communication, their outreach activities, mentorship skills, enthusiasm for research, and increased awareness of K-12 education limitations and appropriate activities and feedback from focus groups. We were unable to locate a validated survey on the effects of mentoring on the mentors so we developed our own survey to measure the impacts of participating as scientist mentors for the project teachers. The development of this survey is described in detail in the methods and measures section.

Expected Outcomes	*Data Sources*
Increased research productivity – benefit to the project	Contributions of mentees to the project Mentor survey on benefits to mentors (increase interest in profession, pay back, pay forward, etc.)
Increased ability to communicate relevance of research to the public	Mentor survey - changes in communication techniques Presentations to the public (fireside chats, conference presentations, library, etc.) Anecdotes about some specific concept they learned to communicate better
Expanded outreach	Outreach activities – audience, location, duration, frequency
Improved mentorship skills	Focus groups: Successful practices; Perceived impact/influence on mentee and why/how; Advice for other mentors
Increased awareness of the limitations and demands of the K12 education system	Focus groups: Mentors can describe prior vs. enhanced understanding of limitations and opportunities working in K-12
Increased awareness of the disconnect between K12 education and higher education	Focus groups: Mentors can identify the instances and disconnect points and the additional or alternative support required
Increased awareness of age appropriate activities	Able to identify changes in which concepts and how concepts are introduced to students for at least two different levels (e.g. middle and high school)
Increased enthusiasm for	Mentor survey: How likely scientists are to participate in a

research	similar program Recommendation to others?
Expanded sense of community for teachers and scientists	Network analysis to include expanded sense of community, knowledge development, and value creation.

Research Question: ***How and why did the project have impact on teachers and scientists?***

The research focused on understanding the nature and extent of the impact on teachers and the scientists. First, to understand the impact on teachers, we asked them to complete two surveys on the impact of the program on their identity as STEM teachers, their understanding of the nature of science, and their teaching practice. We asked the teachers to complete these surveys prior to our reunion to help develop our understanding of the impacts. We followed-up these survey findings with focus groups at the reunion to expand our understanding and clarify comments from the surveys.

Through the use of multiple sources, we were able to characterize the nature and extent of the impact. Analysis of their lesson plans and focus group data will contribute to creating a full picture of each teacher.

We also asked the scientist mentors to complete a survey that we developed and validated as well as participate in focus groups while at the reunion. The data we collect allowed us to build our understanding of the impact on the scientists acting as mentors for the teachers as well as the impact on the mentors themselves.

Research Questions for Teachers

Research Questions	Data Sources
In what ways did working with scientists on an ongoing research project affect the teachers?	Teacher focus groups to identify the ways in which they were affected (STEM teaching identity, understanding of the nature of science) and what about the nature of the experience caused those effects (international, immersion, contact with scientists)
In what ways did the effects of the research experience affect teachers' teaching?	Case studies based on structured interviews asking about how the effects identified translated into changes in their practice (overall, not just in their lesson) and how they view the teaching of science, the nature of science, and their role as science teachers

Research Questions for Scientists

Research Questions	Data Sources
In what ways did working with the teachers on their research project affect the scientists?	Scientist's essays to identify the ways in which they were affected (STEM identity, understanding of the nature of science) and what about the nature of the experience caused those effects (international, immersion, working with teachers, sharing science and practice)

In what ways did the research experience affect scientists' practice?	Structured interviews asking about how the effects identified translated into changes in their practice and how they view the importance of science, the nature of science, and their role as scientists

B. Measures – Detailed Information

STEBI-A Item Analysis

The STEBI is an instrument based on Bandura's definition of self-efficacy as a situation-specific construct. The instrument was developed by Riggs and Enochs (1990) to measure efficacy in teaching science for elementary teachers while a number of studies have used it successfully with middle school and high school teachers (Holden, Groulx, Bloom, and Weinburg, 2011). There are two forms, the Science Teaching Efficacy Belief Instrument form A (STEBI-A) for in-service teachers (Riggs & Enochs, 1990) and form B for pre-service teachers. We employed the STEBI-A with our in-service teachers.

The Personal Science Teaching Efficacy Belief (PSTE) items measure science teachers' confidence in their ability to teach science and the Science Teaching Outcome Expectancy (STOE) items measures science teachers' beliefs that student learning can be influenced by effective teaching. Participants used a five-point Likert-type scale to respond to each of the 23 statements by selecting one of the following responses: strongly agree (5), agree (4), are uncertain (3), disagree (2), or strongly disagree (1). Any positively worded statement is scored by awarding five points for 'strongly agree' responses, four points for 'agree' responses, and so forth. Negatively worded statements are scored by reversing the numeric values (5=1), (4=2), (2=4), and (1=5). The possible range of PSTE scores is 13 to 65. The range of STOE scores is from 10 to 50. The scores of the PSTE and STOE do not add up to a total score, since they measure different aspects of science teaching self-efficacy. Reliability coefficients for the two scales were .82 and .75 for the PSTE and STOE, respectively.

Steps in scoring the STEBI-A

Step 1: Reverse Selected Response Values

As the tool was designed, a number of items are negatively worded. The following items were reverse scored in order to produce consistent values between positively and negatively worded items. Reversing the scores of these items produces high scores for those high and low scores for those low in efficacy and outcome expectancy beliefs - reverse score items – 1,2,4,5,7,9,11,12,14,15,16,18,23; recoded items – (5=1), (4=2), (2=4), (1=5)

Step 2: Sum Scale Items

Items from the two scales are scattered randomly throughout the STEBI. The scale designed to measure Personal Sense Teaching Efficacy Beliefs includes items 2, 3, 5, 6, 8, 12, 17, 18, 19, 21, 22, 23, and 24. The scale designed to measure Science Teaching Outcome Expectancy includes items 1, 4, 7, 9, 10, 11, 13, 14, 15, 16, 20, and 25.

Teacher Efficacy and Attitudes Toward STEM Survey (Friday Institute for Educational Innovation, 2012)

The survey invites teachers to give information about:

- Their self-efficacy for teaching;
- Their belief that teachers affect student learning;
- How often students use technology;
- How often they use certain STEM instructional practices;
- Their attitudes toward 21st century learning;
- Their attitudes toward teacher leadership; and
- Their awareness of STEM careers.

We chose to use the T-STEM survey instrument designed for science teachers. The T-STEM enabled us to learn more about teachers' sense of self-efficacy after their experience, how they believed they were able to affect their students, how they were incorporating STEM instructional practices, and their awareness of STEM careers. The T-STEM is a well-established tool for measuring changes in teachers' self-efficacy as a result or engagement in professional development programs designed to change how teachers engage with their students and incorporate technology and career information into their curriculum (Unfried, Faber, Stanhope, and Wiebe, 2015).

C. Mentor Survey

Mentoring of pre-service professionals including teachers is a common practice in and outside of formal settings. It is common to hear from mentors about the positive effect of mentoring on the mentor, but a validated mentor survey to look at effects of mentoring educators could not be located. Some of the benefits to mentors are described in the passage below:

> *Mentoring provides the mentor with numerous benefits, including enhancement of his or her own personal and professional knowledge while teaching and learning from the mentee. By providing guidance, support, advice, strategic feedback, and other insights to a mentee, the mentor can learn and enhance leadership skills. Mentees often bring a fresh perspective to a difficult problem, and serving as a mentor can provide a renewed sense of purpose in meeting the challenges of leading an educational endeavor or a research program. While working with a mentee, the mentor also has the opportunity to gain a new talented colleague—one with whom the mentor may collaborate for years to come. Most of all, a mentor is provided with an important sense of satisfaction in contributing to a legacy of developing the next generation of creative faculty.*
> (https://www.icre.pitt.edu/mentoring/overview.html).

While this is an important statement about the benefits of mentoring on mentors, we could not locate a validated instrument with research results to support these claims so we developed and validated a tool.

Survey Framework

The survey includes both cognitive and affective dimensions.

A. Cognitive Domain - Mentoring, Teaching, Understanding of K-12
    - How has being a mentor helped scientists become better scientists?
    - How does participation as a mentor change their understanding of K-12 learning, instruction, communication, and teacher practice?
B. Affective Domain- Professional, Personal, Participation

- How does participation as a mentor result in changes in their interests, opinions, and attitudes towards teachers, K-12 learning, lesson development, and implementation of the scientific method?
- How does participation as a mentor result in changes in their personal and professional lives?

Protocol to Establish Validity and Reliability
The table below shows the types of validity and reliability types used for the mentor survey (Burton and Mazerolle 2011).

Type	Description	Purpose
Face Validity	Evaluation of an instrument's appearance by a group of experts and/or potential participants.	Establish the mentor survey as easy to use and clear and readable
Content Validity	Evaluation of an instrument's representativeness of the topic to be studied by a group of experts.	Establish the mentor survey as credible. From reviewers, establish accuracy, relevance, and breadth of knowledge regarding the domain.
Construct Validity	Evaluation of an instrument's ability to relate to other variables or the degree to which it follows a pattern predicted by a theory.	Establishing mentor survey as able to evaluate the construct it was developed to measure.
Test-Retest Reliability	This approach assumes that there is no substantial change in the construct being measured between the two occasions.	Administered the mentor survey to a subset of the mentors on two different occasions (4 days apart).
Internal Consistency Reliability	A single measurement instrument administered to a group of people on one occasion with multiple questions for each topic	The reliability of the mentor survey was estimated by how well the items that reflect the same construct yield similar results. We examined how consistent the results were for different items for the same construct within the survey.

D. Process
The process for validating the mentor survey had five steps: 1) defining the constructs we wanted to examine, 2) generating items that would test those constructs, 3) pilot testing the items, 4) analysis of pilot data, 5) test-retest data collection and analysis.

1. Defining Constructs
Cognitive Domain

- Mentoring, Teaching, Understanding of K-12
  - How has being a mentor helped scientists become better scientists?
  - How does participation as a mentor change their understanding of K-12 learning, instruction, communication, and teacher practice?

Affective Domain

- Professional, Personally, Participation
    - How does participation as a mentor result in changes in their interests, opinions, and attitudes towards teachers, K-12 learning, lesson development, and implementation of the scientific method?
    - How does participation as a mentor result in changes in their personal and professional lives?

2. Item Generation and Representativeness

Potential survey items were developed based on a review of existing tools and research on the mentoring that noted any effects on mentors. Each item was developed to meet the research goals and examine the expected outcomes. After the project team completed the items, experts were enlisted in both the field of survey development and mentoring to review our survey tool for alignment to both domains as well as item consistency, likelihood to elicit the required response, and wording. An email was sent to the eight experts (5 content, 3 survey development) outlining the process (attached below).

Email sent to reviewers

Good morning,

We are developing a mentor impact survey as part of a RET summative evaluation effort and I would like to ask for your help as a professional with experience in survey development and mentoring. I have attached the mentor impact survey we have developed and ask you to do the following:

Check for Face Validity

- Do the items on the survey capture our topic? Will the survey we have developed measure what we intend?

To help you determine this, I have attached some background as well as our survey framework. In the framework, you will see that we are primarily interested in two areas: the cognitive domain and the affective domain and have two research questions for each that the survey is designed to gather information in the hopes of answering. Please write your feedback either directly on the survey (with any suggested edits to the items) or in an email back to me.

If you have any questions or concerns, please call or write to me directly and I will be happy to discuss them with you. Time is always short so I would like to hear back from you at your earliest convenience but no later than June 8th. If you are unable to assist, please let me know ASAP so I can find a suitable replacement.

Thank you in advance for your help and support!

Best,

Brad

Background

Mentoring of pre-service professionals including teachers remains a common practice in and outside of formal settings. Much has been written about the highly impactful nature of being in a mentor-mentee relationship and in the case of teachers, the impact on the mentored teachers' students as well. Additionally, people who have been a mentor report it benefits them as well. While it seems intuitive that mentoring will result in impacts on the mentor, little has been studied on this impact.

It is not uncommon to read about the impact of mentoring on mentors. A quick search might find something like this.

> "Mentoring provides the mentor with numerous benefits, including enhancement of his or her own personal and professional knowledge while teaching and learning from the mentee. By providing guidance, support, advice, strategic feedback, and other insights to a mentee, the mentor can learn and enhance leadership skills. Mentees often bring a fresh perspective to a difficult problem, and serving as a mentor can provide a renewed sense of purpose in meeting the challenges of leading an educational endeavor or a research program. While working with a mentee, the mentor also has the opportunity to gain a new talented colleague—one with whom the mentor may collaborate for years to come. Most of all, a mentor is provided with an important sense of satisfaction in contributing to a legacy of developing the next generation of creative faculty" (https://www.icre.pitt.edu/mentoring/overview.html).

Our goal is to investigate these kinds of claims.

Survey Framework

Cognitive Domain

Mentoring, Teaching, Understanding of K-12

- How has being a mentor helped scientists become better scientists?
- How does participation as a mentor change their understanding of K-12 learning, instruction, communication, and teacher practice?

Affective Domain

Professional, Personally, Participation

- How does participation as a mentor result in changes in their interests, opinions, and attitudes towards teachers, K-12 learning, lesson development, and implementation of the scientific method?
- How does participation as a mentor result in changes in their personal and professional lives?

3. Pilot Testing

The pilot testing of the mentor survey was conducted on a subset of the intended population. Eight mentors were asked to complete the survey a first time and then within a week later to examine test-retest reliability (Burton & Mazerolle, 2011). Follow up reminders were sent to ensure that all of the mentors completed the survey both times. Once the surveys were completed both times, the responses were reviewed for consistency to establish reliability for the instrument. The results showed strong correlations between tests on both open-ended responses and quantitative items.

4. Analysis

In the analysis of pilot data, the survey was checked for internal consistency, inter-item consistency, item min and max discrepancies, and reversed responses.

Factors and Items (3+ items/factor)

Factors	**Items**
Professional	Have there been any changes in your work as a scientist as a result of your GABI experience? Explain how mentoring a teacher on their project influenced your scientific process. Being a mentor to teachers benefits scientists as scientific professionals (rate agreement before/after)
Mentoring	What did you learn about mentoring from working with the teachers during this experience? What did you learn about mentoring from working with the teachers during this experience? What was the biggest surprise for you about mentoring during your GABI mentoring experience? Being a mentor persuaded me that this program was worthwhile for me as a mentor (rate agreement) Being a mentor was a positive experience in which I would participate again in the future (rate agreement)
Teaching	Being a mentor to teachers benefitted scientists as educators (rate agreement) Being a mentor to teachers benefitted teachers (rate agreement) I have better understanding of working in the classroom with K-12 students (before/after rating)
Personal	What have you learned about yourself from mentoring in GABI RET? How has your GABI mentoring experience affected you personally? Being a mentor to teachers benefitted scientists as individuals (rate agreement) Being a mentor and working with the teachers was a learning experience for me (rate agreement)
Participation with K-12	What continued collaborations (papers, classroom visits, conference presentations, etc.) have you had with any of the teachers? As a result of my participation, I have a greater interest in teaching in K-12 settings (rate agreement)

	I would like to be a mentor to a K-12 teacher in the future (rate agreement)
Understanding of K-12	What did you learn about teaching and learning from working with your teacher partners? Being a mentor caused me to reevaluate my views about the demands and needs of K-12 teachers (rate agreement) Being a mentor persuaded me that these kinds of research experiences are worthwhile for teachers (rate agreement)

5. Test-Retest

The last step in validating our mentor survey instrument was the test-retest phase. Test-retest helped us to test the stability and reliability of our instrument over time. A confounding factor in test-retest is extended periods of time between the two test taking periods. For our work, we had a group of six scientists take the survey and then take it again within a week. Once the scientists had taken the survey twice, their quantitative responses were compared using a Pearson Correlation. The results for each scientist are below.

Correlation of numeric responses

Scientist/Mentor	Numeric Response Correlation
1	0.81
2	0.94
3	0.97
4	1.0
5	0.89
6	0.95

Mean test-retest correlation is 0.93 indicating a very high correlation or very strong test-retest reliability for the quantitative survey items.

For the open-ended responses, our lead evaluator and a program graduate student independently read each response, identifying key ideas or concepts, and indicating any responses that they believed to be significantly different. Their analyses were then compared with a review by a third researcher. Overall, a total of four of the 42 open-ended responses were found to be significantly different as determined by the three reviews (10%). This shows a reliability correlation for the qualitative analysis of open responses of 0.90 or highly correlated. Being satisfied with our test-retest reliability testing, we sent the survey to the remaining mentors to complete. A sampling of the mentor open-ended responses appears as Appendix A. Results are reported in the Findings section in sub-section L.

E. Research Questions, Tools, and Items for Teachers

In what ways did working with scientists on an ongoing research project affect the teachers?

Indicate the importance of each of the following learning outcomes from your field experience: (1=not at all important, 10=highest importance)

- Enhanced critical thinking and problem-solving skills

- Development of social and professional relationships with peers and scientists
- Increased confidence in working with "real" data and problems
- Integrated knowledge from a range of sources
- Developed paleontology expertise
- Developed proficiency in field skills
- Developing scientific behaviors such as researching, asking questions, using data, communicating results, etc.
- Learned how paleontologists think and reason

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement. "I know …" (SD=Strongly Disagree, D=Disagree, N=Neither Agree or Disagree, A=Agree, SA=Strongly Agree)

- About current STEM careers
- Where to go to learn more about STEM careers

Personal science teaching efficacy beliefs (PSTE)

- I am continually finding better ways to teach science.
- Even when I try very hard, I don't teach science as well as I do most subjects.
- I know the steps necessary to teach science concepts effectively.
- I am not very effective in monitoring science experiments.
- I generally teach science ineffectively.
- I understand science concepts well enough to be effective in teaching elementary science.
- I find it difficult to explain to students why science experiments work.
- I am typically able to answer students' science questions.
- I wonder if I have the necessary skills to teach science.
- Given a choice, I would not invite the principal to evaluate my science teaching.
- When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.
- When teaching science, I usually welcome student questions.
- I don't know what to do to turn students on to science.

Open-Ended Questions

Have you presented at a professional conference (teacher focused or STEM focused) that describes your experience resulting from this project?

If you have presented at a professional conference, which one(s)?

Have you continued to collaborate with any of the STEM scientists you have meet as a result of this project.

If you have continued to collaborate with any of the STEM scientists who are they and how have you collaborated?

In what ways did the effects of the research experience affect teachers' teaching?

Indicate the importance of each of the following learning outcomes from your field experience: (1=not at all important, 10=highest importance)

- Utilized field experiences to develop lessons and lesson plans
- Developed ways to translate field experience into classroom activities

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement. "I know …" (SD=Strongly Disagree, D=Disagree, N=Neither Agree or Disagree, A=Agree, SA=Strongly Agree)

- Where to find resources for teaching students about STEM careers
- Where to direct students or parents to find information about STEM careers

During science instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.) how often do your students… (N=Never, O=Occasionally, A=About half the time, U=Usually, E=Every time, NA=Not Applicable)

- Develop problem-solving skills through investigation (e.g. scientific, design or theoretical investigations)
- Work in small groups
- Make careful observations or measurements
- Use tools to gather data (e.g. calculators, computers, computer programs, scales, rulers, compasses, etc.)
- Recognize patterns in data
- Create reasonable explanations of results of an experiment or investigation
- Choose the most appropriate methods to express results (e.g. drawings, models, charts, graphs, technical language, etc.)
- Complete activities with a real-world contact
- Engage in content-driven dialogue
- Reason abstractly
- Reason quantitatively
- Critique the reasoning of others
- Learn about careers related to the instructional content

"I think it is important that students have learning opportunities to…" (SD=Strongly Disagree, D=Disagree, N=Neither Agree or Disagree, A=Agree, SA=Strongly Agree)

- Lead others to accomplish a goal
- Encourage others to do their best
- Produce high quality work
- Respect the differences of their peers
- Help their peers
- Include others' perspectives when making decisions
- Make changes when things do not go as planned
- Set their own learning goals
- Manage their time wisely when working on their own
- Choose which assignment out of many needs to be done first
- Work well with students from different backgrounds

Science teaching outcome expectancy (STOE)

- When a student does better than usual in science, it is often because the teacher exerted a little extra effort.
- When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.
- If students are underachieving in science, it is most likely due to ineffective science teaching.
- The inadequacy of a student's science background can be overcome by good teaching.
- The low science achievement of some students cannot generally be blamed on their teachers.
- When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.
- Increased effort in science teaching produces little change in some students' science achievement.
- The teacher is generally responsible for the achievement of students in science.
- Students' achievement in science is directly related to their teacher's effectiveness in science teaching
- If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.
- Effectiveness in science teaching has little influence on the achievement of students with low motivation.
- Even teachers with good science teaching abilities cannot help some kids learn science.

Open-Ended Questions

How has immersion in practice through participation in GABRI RET evolved your classroom practice to engage students in the scientific process?

How are you implementing the scientific process in your lesson planning and teaching?

How many lesson plans have you developed and implemented resulting from this experience?

What was the specific content of each of the lesson plans you developed and used?

III. Detailed Findings

In this section, we summarize the participant data, followed by data for each question. The following gives a listing of the different sub-sections and a description of what the sub-section contains.

Sub-Section	Description
A. Participant Demographics	Description of the teacher participants, their ethnicity, backgrounds, and professional area of focus
B. Scientist Mentors	A listing of the scientists and their cohort
C. Sharing and Collaborations	Listing of collaborations by program teachers and numbers of audiences reached. Website and web metrics.
D. In what ways did working with scientists on an ongoing research project affect the teachers?	Findings from all data sources focused on detailing the impact of working with scientists for the teachers.
E. GABI RET Teacher Causal Chain Summary	Detailed findings of why teachers joined the program, what they hoped to accomplish, how the program design helped them meet their objectives, what they did with what they learned, and what outcomes came from their experience.
F. In what ways did the effects of the research experience affect teachers' teaching?	Findings from all data sources focused on detailing the impact of participating in the program on teachers' classroom practice.
G. How are you implementing the scientific process in your lesson planning and teaching?	Analysis of teachers' lessons for how they are incorporating the scientific process in their lessons to develop students' ways of thinking and acting as scientists based on their own experience in GABI.
H. Educator Lesson Plan Summary	Teachers' lesson plans and their reflections on using them.
I. 2014 – 2016 Field Practices	To illustrate how teachers transferred their experiences from the field directly into classroom experiences for their students, we have listed field practices and activities that the teachers participated in while in Panama and listed the classroom practices developed from the many experiences.
J. Social Network Analysis	For the 22 educators that attended the summit, the connections they had made as a result of the project.
K. Impact on Teachers' Knowledge	Teachers were asked to complete an eight-question knowledge test about key concepts associated with the GABI and the teachers' experience.

A. Program Participant Demographics
The largest group of respondents was to the Teacher Practice and Effects Survey (42/29 contacted). A summary of their demographics reveal a largely non-Hispanic (93%) white (86%)

female teacher group (79%) with a wide range of teaching experience from early-career teachers (1-4 years– 9%), mid-career teachers (5-15 years– 53%) and longer-career (16-30+ years– 38%) teaching 5-8 (50%) and 9-12 (43%) grades. The teachers currently teach a variety of different subjects including biology (45%), Earth science (35%), and general science (26%). Thirty of the teachers (71%) had also participated in a number of other field experiences while teaching or in college, such as summer workshops, and other international experiences.

These demographics suggest that this experience appealed to teachers with some classroom experience. GABI RET also appealed to teachers who had had previous field experiences. The interdisciplinary nature of paleontology allowed teachers from different disciplines to participate.

Gender

	N	%
Male	9	21%
Female	33	79%

Please select the racial category or categories with which you most closely identify

	N	%
American Indian or Alaskan Native	2	5%
Asian	1	2%
Black or African American	0	0
Native Hawaiian or Pacific Islander	0	0
White	36	86%
Some other race	3	7%

Please indicate your ethnicity

	N	%
Hispanic/Latino	3	7%
Non-Hispanic/Latino	38	93%

How many years have you been an educator?

# Years	N	%
<1	0	0
1-2	1	2%
3-4	3	7%
5-6	4	10%
7-8	6	14%
9-10	5	12%
11-15	7	17%
16-20	5	12%
21-25	8	19%
26-30	0	0
>30	3	7%

What age group(s) do you teach? (Check all that apply)

	N	%
K-4	3	7%
5-8	21	50%
9-12	18	43%

Other described

- *K-12 superintendent and consultant*
- *I have taught middle school, I currently teach high school.*
- *I taught 5th grade, and 8-12 Alternative Education, but now I am a Coordinator of Curriculum & Instruction (admin)*
- *Earlier during GABI RET participation I taught 8th grade, but this year I am teaching high school.*
- *In the classroom, I most recently worked with middle school children. For the past 10 years, I have also worked with classroom teachers K-12, supporting them in a transition to project based science practices and in the use of NGSS three-dimensional learning.*
- *Science Coordinator*

What subject(s) do you currently teach?

Subject	N	%
Biology	19	45%
Chemistry	4	10%
Earth Science	15	36%
Engineering	0	0
General Science	10	24%
Geology	6	14%
Mathematics	2	5%
Physics	4	10%

Other

- *Environmental Science, Environmental Management (6)*
- *Art (2)*
- *Language Arts (2)*
- *NGSS Integrated Science (2)*
- *Assistant principal*
- *Retired superintendent of schools, education consultant*
- *History*
- *3rd grade (all subjects)*
- *Experimental Design*
- *Education Technology for Teachers and Administrators*
- *Educator professional development*
- *AP Biology*
- *Anatomy, physiology*
- *Physical Science*

What other field experiences have you had in addition to your GABI RET experience?

- *Nebraska*
- *Summer workshop hosted by UF, digging at Thomas Farms*
- *Earthwatch Coastal Ecology of the Bahamas Research Assistant 2009-2012*
- *Cedar Key Marine Organism Identification, Honduras SCUBA internship Marine ecosystems*
- *Montbrook trip*
- *Volunteer paleo, environmental and archeology activities in other Latin American localities and North America*
- *3 months in Belize, 3 months in California undergrad biology and ecology research with professors, small student cohorts, and post-docs*
- *TWIN Wolf Census in Wisconsin*
- *I used to teach outdoor education on Catalina Island - Catalina Island Marine Institute (more kids rather than research though).*
- *ITEST participant, no other field experiences*
- *Occasional field trips with scientists as a journalist*
- *Years of amateur fossil hunting and also archaeological digs with FMNH staff.*
- *UF IFAS PLANT CAMP 2016*
- *Collected Herps in Honduras for FLMNH; Trapped Sandhill Cranes; Collected Mosquitoes for USDA; Mist netted bats foe UTAH Fish and Wildlife; Collected Inverts for the Cincinnati Zoo; Dredging for marine specimens with UF*
- *LIMPETS; Elkhorn Slough's Teacher Outdoor Education Program; Salmon and Trout Program*
- *I had the opportunity to attend the PIRE wrap up session. Other than those two experiences, I did a little field work with my undergrad, but not much.*
- *Teachers on the Estuary Training with the Elkhorn Slough Reserve.*
- *NSF funded field work in SW Oregon on wildfire hazard in the urban/rural interface; and visiting teacher aboard the JOIDES Resolution*
- *Working on a Scripps Institute Research Ship; Acting as an intern at the Ano Nuevo Elephant Seal rockery; Participating in identifying and recording intertidal invertebrates at Big Creek reserve in Big Sur*
- *California Naturalist Certification Program; Monterey Bay Aquarium Teacher Institutes*
- *Just in college*
- *SCWIBLES working in various field experiences*
- *La Selva Biological Research Station, also Panama plant pathology research*
- *Some Earth Science experiences during my master's degree*
- *Field work with the New Mexico Museum of Natural Science*
- *Informal fossil hunting; One day dig at Thomas Farm a while ago*
- *Field research in Costa Rica, involving territorial behavior in humming birds; Nest monitoring for The Nature Conservancy.*
- *I worked with John Pearse to develop the LIMPETS program and I've worked as part of the district watershed. I also collected data in the field for two years on species richness in the intertidal.*
- *Another RET with UCSC working on climate change modeling and reptile response.*
- *Working with you all in Florida at two sites*

B. Scientist Mentors

Responding Scientist Mentors by cohort (scientists can be in more than one cohort)

Cohort	N	%
2012 (Cohort 1)**	1	7%
2013 (Cohort 2)**	2	13%
2014 (Cohort 3)	4	26%
2015 (Cohort 4)	7*	47%
2016 (Cohort 5)	7*	47%

*Four of the scientists participated in both the 2015 and 2016

** Previous project PCPPIRETeach

C. Sharing and Collaborations

The educators attending the summit were asked to indicate the number of the different audiences they shared resources with since participating in GABI RET. We found that the educators had reached a total of nearly 7000 people directly (112 administrators, 468 educators, 5050 students, 1087 parents, 232 public) and we estimate an additional 10,000+ from media coverage.

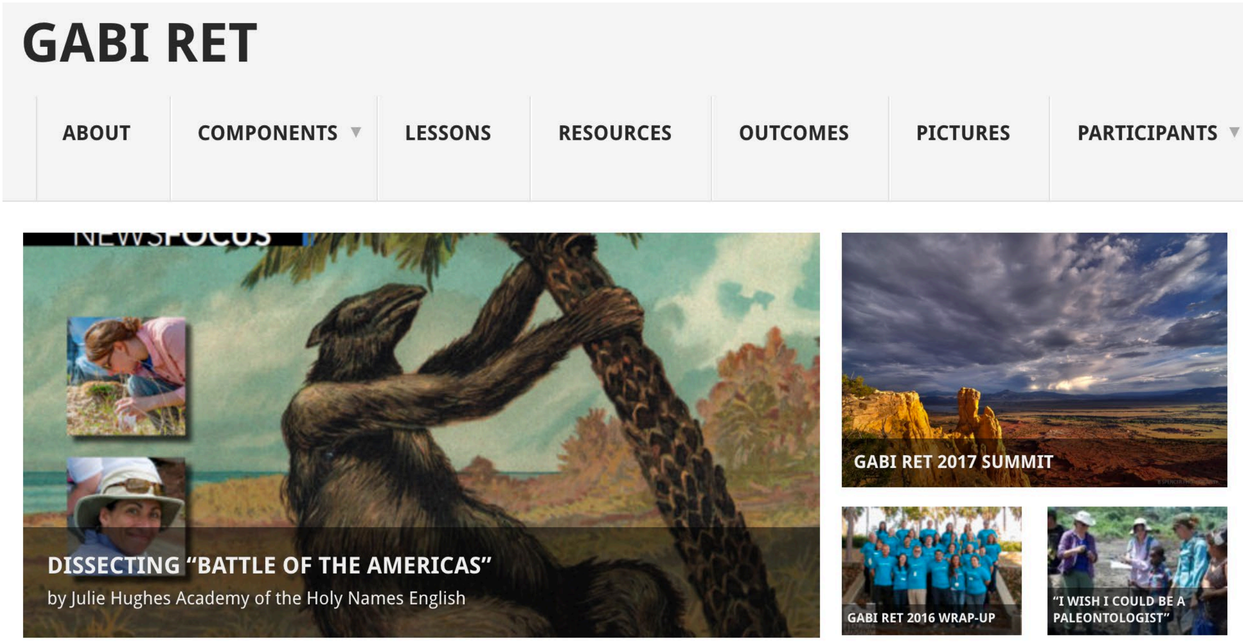
	Totals from 22 Educators
Administrators	112
Educators	468
Students	5050
Parents	1087
General Public	232
Social Media	500+ est
Media	10,000+ est
Other	40

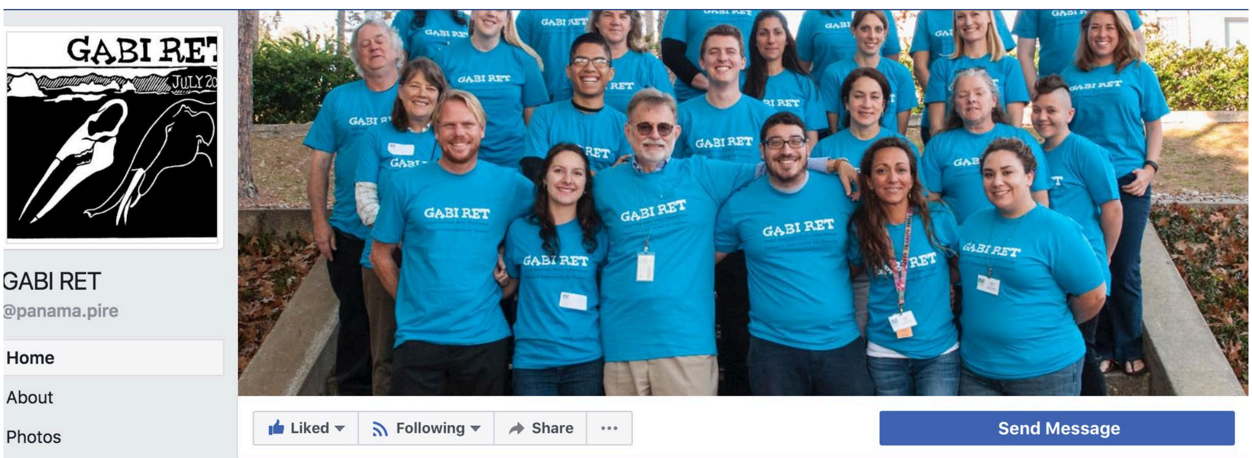
Other described

- Friends and family

Both the teachers and the scientists involved in the program represented a diverse group coming from varied backgrounds and prior experience. Teachers taught a variety of different subjects from math to language arts and a range of grades from elementary through high school. The teachers also had various levels of prior experience in the field. For the mentors, many were new to field work themselves and had little experience working with teachers or their students. Other mentors had extensive field experience and had worked with teachers in a variety of ways. Despite the diversity of experience, disciplines, and backgrounds, both the teachers and scientists consistently reported that GABI RET positively affected both their professional practice and knowledge of paleontology and teaching practices and crosscutting concepts.

The GABI RET website has a listing of all of the participants from each year, lesson plans and projects they developed, resources, contact information for project leads, and a listing of events past and present.





The GABI RET Facebook page represents another avenue for the community to continue their collaborations and communications while learning about what others are doing and making new connections. The GABI RET Facebook page currently has 386 followers and 397 page "likes." Through the Facebook pages, the GABI RET team has reached over 1500 people in 46 different countries, and 19 different languages. Over an average month, postings to the page reach an average of 156 people ranging from as few as 43 to as many as 489.

D. How working with scientists affected the teachers

The teachers were asked about the importance of a number of different learning outcomes from their field experience. The teachers rated the development of social and professional relationships with peers and scientists highest (8.9/10) followed by learning how paleontologists think and reason (8.5), developing ways to translate field experience into classroom activities (8.5), developing proficiency in field skills (8.4), and utilizing field experiences to develop lessons and lesson plans (8.4).

Indicate the importance of each of the following learning outcomes from your field experience: (1=not at all important, 10=highest importance)

	Mean
Enhanced critical thinking and problem-solving skills	8.1
Development of social and professional relationships with peers and scientists	8.9
Increased confidence in working with "real" data and problems	8.0
Integrated knowledge from a range of sources	8.2
Developed paleontology expertise	8.3
Developed proficiency in field skills	8.4
Developing scientific behaviors such as researching, asking questions, using data, communicating results, etc.	8.0
Learned how paleontologists think and reason	8.5
Developed ways to translate field experience into classroom activities	8.5
Utilized field experiences to develop lessons and lesson plans	8.4

When asked about their knowledge relating to STEM careers, the teachers reported significant changes in their belief about their knowledge of STEM careers (3.4/5 pre, 4.7/5 post), where to go to learn more about STEM careers (3.4, 4.5), where to find resources for teaching students about STEM careers (3.2, 4.5), and where to direct students or parents to find information about STEM careers (3.0, 4.1).

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement. "I know …" (SD=Strongly Disagree, D=Disagree, N=Neither Agree or Disagree, A=Agree, SA=Strongly Agree)

STEM Careers (N=22)

	Mean Response		**Post % Agree or Strongly Agree**
	Pre	Post	
About current STEM careers	3.4	4.7*	100%
Where to go to learn more about STEM careers	3.4	4.5*	95%
Where to find resources for teaching students about STEM careers	3.2	4.5*	91%
Where to direct students or parents to find information about STEM careers	3.0	4.1*	77%

*Indicates a significant difference pre/post ($p \leq 0.01$)

The teachers had a mean pre-score of 54.3 on the PSTE section of the STEBI (min=27, max=65, SD=8.5) and a significantly different ($p \leq 0.01$) mean post score of 60.4 (min=55, max=65, SD=3.7). The teachers had a mean pre-score of 38.4 on the STOE section (min=30, max=46, SD=4.6) and a significantly different ($p \leq 0.01$) mean post score of 42.8 (min=31, max=55, SD=4.8). These scores are in-line with or higher than what other studies have reported for post experience teachers mean scores (ESI, 2014; Holden, et al., 2011; Savage, 2004). These high post experience scores reveal a high self-efficacy among the program teachers after their GABI RET experience.

STEBI-A Teachers Scores (N=22)

	Mean Pre-Score	**Min Score**	**Max Score**	**SD**
Personal science teaching efficacy beliefs (PSTE)	54.3	27	65	8.5
	Mean Post Score	Min Score	Max Score	SD
	60.4*	55	65	3.7

*Indicates a significant difference pre/post (p≤0.01)

STEBI-A Survey Tool – Items for the PSTE Scale

	Mean Score	
	Pre	Post
I am continually finding better ways to teach science.	4.2	4.8*
Even when I try very hard, I don't teach science as well as I do most subjects.	1.5	1.4
I know the steps necessary to teach science concepts effectively.	4.0	4.7*
I am not very effective in monitoring science experiments.	1.9	1.7
I generally teach science ineffectively.	1.5	1.3**
I understand science concepts well enough to be effective in teaching elementary science.	4.2	4.6**
I find it difficult to explain to students why science experiments work.	2.0	1.4*
I am typically able to answer students' science questions.	4.0	4.5*
I wonder if I have the necessary skills to teach science.	2.0	1.4*
Given a choice, I would not invite the principal to evaluate my science teaching.	2.1	1.5*
When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	1.9	1.4*
When teaching science, I usually welcome student questions.	4.6	4.9
I don't know what to do to turn students on to science.	2.1	1.3*

*Indicates a significant difference pre/post (p = ≤0.01)

**Indicates a significant difference pre/post (p = ≤0.05)

Have you presented at a professional conference (teacher focused or STEM focused) that describes your experience resulting from this project?

	N	**%**
Yes	10	29%
No	25	71%

If you have presented at a professional conference, which one(s)?

	N	**%**
ISTE	5	12%
NSTA (regional and national)	2	5%
Fossil Professional Development in Santa Cruz, CA	1	2%
Geologic Society of America	1	2%
School board	1	2%

Have you continued to collaborate with any of the STEM scientists you have met as a result of this project?

	N	%
Yes	23	66%
No	12	34%

If you have continued to collaborate with any of the STEM scientists who are they and how have you collaborated?

Summary of Teacher Responses about Mentor Collaborators

Mentor	Collaborations Reported with Project Teachers	%
Sean Moran	11	73%
Bruce MacFadden	9	60%
Claudia Grant	5	33%
John Hendricks	5	33%
Gary Morgan	4	27%
Victor Perez	4	27%
Amanda Waite	3	20%
Catalina Pimiento*	3	20%
Paul Koch	2	13%
Sharon Holte	2	13%
John Block	1	7%
Michelle Barbosa	1	7%
Julie Wuerth	1	7%
Megan Hendrickson	1	7%
Elizabeth Burt*	1	7%
Corey Toler-Franklin*	1	7%

*Only involved in the first year

Summary of Types of Collaborations

Type of Collaboration	N	%
Designed/designed lessons	9	60%
Presented to students/school	7	47%
Sharing resources/support	6	40%
Co-Teaching	2	13%
Field work with scientists	2	13%
Worked with students	2	13%
Developed workshops	1	7%
Projects	1	7%

E. GABI RET Teacher Causal Chain Summary (N=21)

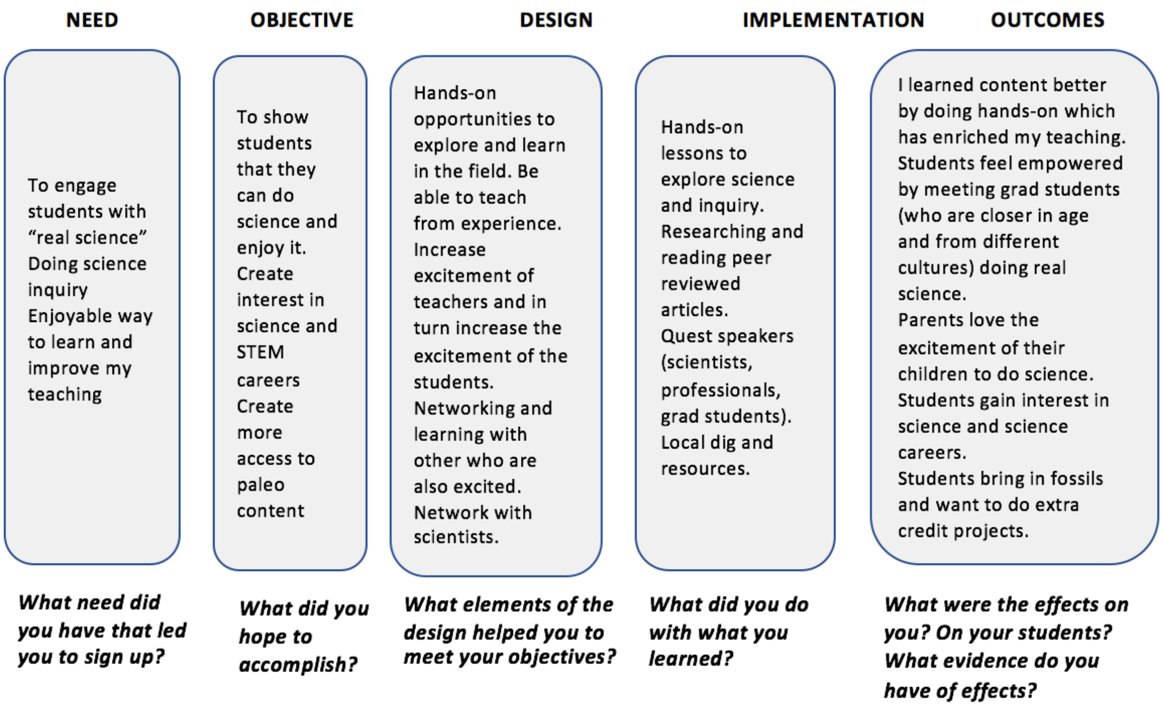
As part of the summit, the teachers were asked to complete a Causal Chain (Davis, Scalice, 2014) to document their experience with the program, from their <u>need</u> for joining the program, what they hoped to accomplish (objectives), how the program design helped them meet their objectives, what they did with what they learned (implementation), and what outcomes came from their experience. A causal chain is a tool originally used in action research and has been adapted to help show the connections from beginning need through to outcomes from the experience.

Examples of Teacher Causal Chains

Individual Causal Chain – Teacher 1

NEED	OBJECTIVE	DESIGN	IMPLEMENTATION	OUTCOMES
Seemed like an amazing opportunity to travel and do fieldwork. I love bones and wanted to learn more about what they could tell me about the past. To bring real science experiences to students. Be able to add context to lessons.	To inspire students to think like a scientist. To remember how exciting it is to discover and learn by doing. To gain confidence in reaching students about paleontology. To gain relevant science knowledge.	Support of other teachers and scientists. Opportunities for field work and being part of the process of science and discovery. Access to resources and a network of people to collaborate with.	I shared my experience with my students. I incorporated GABI ideas into lessons. Put students in the role of scientists rather than just students include more inquiry into my lessons.	Students were willing to take more chances. They became more comfortable with asking questions and sharing ideas. More willing to engage and discuss. Students asked me for articles on fossils and asked me to show them the collection.
What need did you have that led you to sign up?	***What did you hope to accomplish?***	***What elements of the design helped you to meet your objectives?***	***What did you do with what you learned?***	***What were the effects on you? On your students? What evidence do you have of effects?***

Individual Causal Chain – Teacher 2



Overall Summary

A majority of the teachers (81%) reported that the signed-up for the program because they saw it as a learning opportunity, a chance to gain content knowledge, and because they wanted a real-world/authentic science experience (57%). The same percentage (81%) hoped to build their personal and professional knowledge and develop ways to engage their students (57%) and found the hands-on opportunities, learning in the field, and working alongside scientists helped them meet their objectives. The majority of teachers (81%) reported taking what they learned from their field experience and translating it into designing and redesigning classroom lessons and developing hands-on lessons and activities (57%). Teachers saw changes in their understanding of the content and increased confidence (43%), greater interest and engagement of their students (38%), and the value of parents seeing their students being excited about their learning and classroom projects (15%).

The educators were able to easily create these causal chains. They indicate that the program was conducted as advertised, that the design enabled teachers to meet their objectives and implement what they learned, with the intended outcomes of the project.

Summary by Phase

Need – *What need did you have that led you to sign up?*

	N	%
Learning opportunity/content knowledge	17	81%
Experience real-world/authentic science	12	57%
International travel/culture/adventure	10	48%
Collaborations with colleagues/scientists	8	38%

Engage students in/with "real science"	8	38%
New/exciting experience/field experience	7	33%
Enhance curriculum	5	24%

Objective – ***What did you hope to accomplish?***

	N	%
Build personal/professional knowledge	17	81%
Student engagement/real-world to classroom/inspire students	12	57%
Develop/enhance classroom lessons/incorporate paleontology	6	29%
Create interest in science and STEM careers	5	24%
Develop collaborations/relationships	4	19%
Experience science in the field	3	14%
Illustrate active learning for students	3	14%
Enhance personal excitement	2	10%
Gain confidence/credibility	2	10%
Implementation and understanding of scientific process	2	10%
Include international experience in field work	2	10%
Eliminate stereotypes of scientists	1	5%
Look for connections to language arts	1	5%

Design – ***What elements of the design helped you to meet your objectives?***

	N	%
Hands-on opportunities/learning in the field/working alongside scientists	17	81%
Networking/collaborating opportunities with teachers	10	48%
Introductions/collaborations to/with scientists/grad students	9	43%
Professional practices (Pool side chats, scientific papers, scientific teaming, sharing ideas)	9	43%
End of project summit/reengagement	5	24%
Exciting location	5	24%
Artifacts for the classroom	4	19%
Support for teachers/supportive environment	4	19%
Connecting K-12 and higher education practices	2	10%
Lesson planning in Panama	2	10%
Reflecting on practice	2	10%
Access to resources	1	5%
Communication with schools and district by GABI professionals	1	5%
Connections to local/regional references	1	5%
Ideas for experiments and their implementation	1	5%
Museum visits	1	5%
Social media	1	5%

Implementation – ***What did you do with what you learned?***

	N	%
Redesigned/developed lessons (using 5E, unit projects, readings, reflections)	17	81%
Hands-on lessons/inquiry "Students in the role of scientists" "citizen scientists"	12	57%
Guest speakers/expert visits	9	43%
Collaborating with other classrooms/colleagues/co-teaching	7	33%
Developed ways to engage students	5	24%
Embedding scientific process (researching, experimentation, data collection, analysis)	5	24%
Shared experience with students	4	19%
Local experiences/digs	2	10%
Talking about science more	2	10%
Utilize UF resources	1	5%
Website with resources	1	5%

Outcomes – ***What were the effects on you? On your students? What evidence do you have of effects?***

	N	%
Self		
Better understanding of content/increased confidence	9	43%
Reflection on curriculum/teaching	6	29%
More sharing of lessons/collaborations	4	19%
Renewed interest/excitement/enthusiasm in teaching	4	19%
Developing more cross-curricular opportunities	3	14%
Conference presentations	2	10%
More credibility	2	10%
Developed database of lessons	1	5%
Development of more PBL/interactive lessons	1	5%
Evolution as the unifying theme of course	1	5%
More emphasis on science as a career	1	5%
Students		
Greater interest/engagement of students	8	38%
21st Century Skills (taking chances, asking questions, collaborating, sharing, supporting with evidence)	7	33%
Empowered/excited students from visits/talks/guest speakers	7	33%
Student desire to connect with scientists more	3	14%
Increased student achievement	2	10%
Student expressed interest in college STEM courses/programs	2	10%
Students bringing in fossils they found	2	10%
Digital portfolios	1	5%
Improved graphing skills	1	5%
Students identifying unit as their favorite	1	5%
Parents		

Parents seeing student excitement	3	15%
Parent interest at "back-to-school" night	1	5%
Parents requesting a specific teacher	1	5%

F. Ways the research experience affected teachers' teaching

The teachers were also asked about the importance of a number of different learning outcomes from their GABI RET experience. The teachers rated the development of ways to translate field experience into classroom activities (8.5) and utilizing field experiences to develop lessons and lesson plans (8.4).

Indicate the importance of each of the following learning outcomes from your field experience: (1=not at all important, 10=highest importance)

	Mean
Developed ways to translate field experience into classroom activities	8.5
Utilized field experiences to develop lessons and lesson plans	8.4

When asked about their knowledge relating to STEM career resources, 79% agreed or strongly agreed that they know where to find resources for teaching students about STEM careers, and 71% agreed or strongly agreed that they know where to direct students or parents to find information about STEM careers.

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement. "I know …" (SD=Strongly Disagree, D=Disagree, N=Neither Agree or Disagree, A=Agree, SA=Strongly Agree)
STEM Careers

	Mean Response	**% Agree or Strongly Agree**
Where to find resources for teaching students about STEM careers	3.9	79%
Where to direct students or parents to find information about STEM careers	3.7	71%

More than half of the teachers reported engaging their students in a number of activities associated with 21st century skills in the classroom at least half the time with 100% of the teachers using at least one skill set in each class period. The most commonly used methods were working in small groups (81% using this half the time or more), having students engage in content driven dialogue (76% using this half the time or more), helping students develop problem-solving skills through investigation (63% using this half the time or more), having students make careful observations or measurements (62% using this half the time or more), and creating reasonable explanations of results of an experiment or investigation (61% using this half the time or more).

During science learning experiences (e.g. class periods, after school activities, days of summer camp, etc.) how often do your students… (N=Never, O=Occasionally, A=About half the time, U=Usually, E=Every time, NA=Not Applicable)

	A	U	E	Mean
Develop problem-solving skills through investigation (e.g. scientific, design or theoretical investigations)	43%	10%	10%	3.7
Work in small groups	52%	19%	10%	4.2
Make careful observations or measurements	40%	10%	12%	3.8
Use tools to gather data (e.g. calculators, computers, computer programs, scales, rulers, compasses, etc.)	31%	14%	7%	3.6
Recognize patterns in data	40%	7%	10%	3.6
Create reasonable explanations of results of an experiment or investigation	40%	14%	7%	3.7
Choose the most appropriate methods to express results (e.g. drawings, models, charts, graphs, technical language, etc.)	31%	10%	7%	3.5
Complete activities with a real-world contact	33%	12%	10%	3.5
Engage in content-driven dialogue	38%	31%	7%	4.1
Reason abstractly	38%	10%	10%	3.7
Reason quantitatively	36%	7%	7%	3.5
Critique the reasoning of others	24%	7%	7%	3.2
Learn about careers related to the instructional content	12%	10%	7%	3.0

Project teachers were overwhelmingly in agreement on the importance of offering students challenging learning opportunities. They reported significant changes in all areas pre/post GABI experience including helping students to lead others to accomplish a goal (4.3/5, 4.6/5 post), producing high quality work (4.5, 4.9), including others' perspectives when making decisions (4.4, 4.7), making changes when things do not go as planned (4.6, 4.9), helping students set their own learning goals (3.9, 4.5), helping students manage their time wisely when working on their own (4.6, 4.9), choosing when assignment out of many needs to be done first (4.2, 4.7), and work well with students from different backgrounds (4.6, 4.9).

"I think it is important that students have learning opportunities to…" (SD=Strongly Disagree, D=Disagree, N=Neither Agree or Disagree, A=Agree, SA=Strongly Agree)

	Mean Response		% Agree and Strongly Agree
	Pre	Post	
Lead others to accomplish a goal	4.3	4.6*	100%
Encourage others to do their best	4.5	4.7**	100%
Produce high quality work	4.5	4.9*	100%
Respect the differences of their peers	4.6	4.8**	100%
Help their peers	4.7	4.9**	100%
Include others' perspectives when making decisions	4.4	4.7*	100%
Make changes when things do not go as planned	4.6	4.9*	100%

Set their own learning goals	3.9	4.5*	86%
Manage their time wisely when working on their own	4.6	4.9*	100%
Choose which assignment out of many needs to be done first	4.2	4.7*	91%
Work well with students from different backgrounds	4.6	4.9*	100%

*Indicates a significant difference pre/post (p≤0.01)
**Indicates a significant difference pre/post (p≤0.05)

STEBI-A Teachers Scores (N=22)

	Mean Post Score	**Min Score**	**Max Score**	**SD**
Science teaching outcome expectancy (STOE)	38.4	30	46	4.6
	Mean Post Score	Min Score	Max Score	SD
	42.8*	31	55	4.8

*Indicates a significant difference pre/post (p≤0.01)

STEBI-A Survey Tool – Items for STOE Scale

	Mean Scores	
	Pre	Post
When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	3.6	4.0*
When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.	4.0	4.5*
If students are underachieving in science, it is most likely due to ineffective science teaching.	3.2	3.5*
The inadequacy of a student's science background can be overcome by good teaching.	3.8	4.3*
The low science achievement of some students cannot generally be blamed on their teachers.	3.4	3.2
When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.	3.7	4.1*
Increased effort in science teaching produces little change in some students' science achievement.	2.8	2.5*
The teacher is generally responsible for the achievement of students in science.	3.5	3.9*
Students' achievement in science is directly related to their teacher's effectiveness in science teaching	NA	NA
If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	3.8	4.5*
Effectiveness in science teaching has little influence on the achievement of students with low motivation.	1.9	1.5*

Even teachers with good science teaching abilities cannot help some kids learn science.	3.1	2.7*

*Indicates a significant difference pre/post (p≤0.01)

How has immersion in practice through participation in GABRI RET evolved your classroom practice to engage students in the scientific process? (Stating questions/hypothesis, designing a research plan – data collection and data interpretation, and presentation of results)

Engaging students in the scientific process is a powerful way to help them develop the thinking and skills necessary to be successful in STEM (DOE, 2015). When asked how immersion in an ongoing scientific investigation evolved their classroom practice to engage students in the scientific process, all of the teachers were able to give at least one positive example. Most of the teachers (82%) offered more than one example. The examples they gave included having the students ask questions from the perspective of a scientist (20%), offering their own personal stories to engage them (11%), making activities and lessons real-world oriented (11%), and involving students in field experience (9%). The common theme for all of the ways teachers were engaging students is that they all built on actual science professional practices that they had experienced or that were appropriate to the topic of study.

Teacher Response Summary

	N	%
Asking questions from the perspective as scientists	7	20%
Engaging students in the scientific process	7	20%
Adding personal stories	4	11%
Using/sharing real-world examples	4	11%
Involving students in field experiences	3	9%
Collecting and analyzing data	2	6%
Developing scientific arguments	2	6%
Incorporating PBL/IBL	1	3%
Probing students for understanding	1	3%
Taking students into the field	1	3%

Sampling of Teacher Responses

- *Gave me real world examples that I did to lead students through.*
- *Because I have been in the field with scientists and have worked with them to interpret peer-reviewed articles, I feel more comfortable asking questions from the perspective of a scientist and critically analyzing data.*
- *I believe that hands on field type experiences are very valuable to the students. I take every class I teach into the field to participate in experiences that mirror those I had in Panama.*
- *Students love to hear personal scientific stories: my teaching has another layer now, I have field experience working alongside scientists that I never had before. I am a more confident teacher in some regard too. I can now involve students in the scientific process in a more meaningful way.*

- *I am not a classroom teacher but for me the scientific community at STRI, where scientists from multiple disciplines engage with one another, was a strong model for K-12.*

Should fieldwork be an integral part of science teachers' experience? *(focus group)*

- 100% of the teachers said they felt that fieldwork should be an integral part of the teacher experience.
- 100% of the teachers felt that participating in a field experience gave them "credibility" with their students.
- 100% of the teachers felt that participating in a field experience was a way of modeling the importance of being a lifelong learner.
- The teachers were in agreement that field experiences should occur at least annually (100%) or every six months (95%) but commented on the challenges for some teachers of cost and time if they were more frequent

Other comments from the teachers included the importance of "exciting students" by showing them what they had done in Panama, that field work "keep them current" with science and research, that their field experience inspired them, gave them the feeling that they could "really contribute" to science, and that it helped them to see themselves as "legitimate scientists".

> *The idea of fieldwork, and seeing ourselves as legitimate scientists is huge (in the lower grades). All being engaged around a topic, deciding what questions to ask, working in the field (outside the classroom), really enriched my teaching.*

What was the impact on you professionally of this experience? *(Focus group)*

- 100% of the teachers reported that after their experience they felt like they were colleagues with the scientists
- 100% reported they felt they could reach out to scientists and other professionals where before they were hesitant to do so
- 100% of the teachers reported they contacted one of the project scientists at least once a year, 95% twice a year, 64% three times a year.
- 95% Felt that participating helped them feel more confident
- Teachers also talked about making the professional connections, spending the time to "stay current," being inspired to continue teaching, sharing what they learned with other teachers, being seen as a leader in their school, "think out of the box" when developing lessons, being more curious, and gaining a better understanding of how scientists develop knowledge and fight to discover the truth.

> *I'm excited and spend the time to stay more current, and the kids really appreciate it. I email other teachers here and share it with my kids.*

How are you implementing the scientific process in your lesson planning and teaching?
Teachers' lessons show they are incorporating the scientific process in their lessons to develop students' ways of thinking and acting as scientists based on their own experience in the GABI

RET. All of the teachers (100%) described at least one way they were implementing the scientific process into their lesson planning and teaching that was influenced by the GABI RET. Their examples included developing hypothesis (20%), using open-ended questions (17%), incorporating investigations and/or conducting experiments (17%), using evidence (17%), collecting and analyzing data (11%), and using Project Based and Inquiry Based Learning (11%).

Teacher Response Summary

	N	%
Developing hypothesis	7	20%
Establishing/open-ended questions	6	17%
Incorporating investigations/conducting experiments	6	17%
Using evidence	6	17%
Data collection and analysis	4	11%
PBL/IBL	4	11%
All parts/integrated	3	9%
NGSS (3-Dimensional Learning)	3	9%
Observing and asking questions	3	9%
Develop scientific explanations based on evidence	1	3%
Incorporating critical thinking	1	3%
Journaling	1	3%
Promoting scientific literacy	1	3%
Think, speak, read, and write like scientists	1	3%
Using real-life examples	1	3%

Sampling of Teacher Responses

- *Every day. Students make a hypothesis and try to back it up with evidence. They are always being reminded it is OK to change your mind with new evidence.*
- *I am focusing on disciplinary literacy and teaching students to think, speak, read, and write like scientists.*
- *I am using more data collection and analysis and also placing more emphasis on the kids being able to create an argument using evidence.*
- *Students begin by looking at phenomenon. They compose questions then do a series of explorations to find answers to their questions; I guide them in the process. The investigations come in many forms: demos, labs, engineering projects, small group work, reading text and complex text, interviewing scientists.*
- *Having students looking at more data and finding patterns. Transitioning students to collect their own data and interpreting it as well.*
- *My students and I conduct a simulation of an anthropological dig using the process & we have plans for a paleontology dig for the oceanic fossils found in our region (a desert!).*
- *We start with a 'hook' or a problem that students need to solve. Students have been excited about trying to conduct experiments, collect data, and talk about how they can find solutions to explain our phenomena.*
- *I have incorporated journal/notetaking, the debate, archeology/paleopathology, microfossils and the marine fossils, peace river field trip, webinars, and more!*

How many lesson plans have you developed and implemented resulting from this experience?
(N=35)
The 35 teachers completing the Teacher Experience Survey reported developing and implementing a total of 141 lesson plans averaging four for each teacher with a minimum of zero (teacher has designed two but not used them in class yet) and a maximum of 17.

What was the specific content of each of the lesson plans you developed and used?
When asked to describe the specific content of the lesson plans they developed, the teachers named a large variety of lessons including those covering the GABI (23%), the Gatun (20%), Horse tooth and evolution (20%), Megalodon jaw reconstruction (11%), and Megalodon total body length (11%).

Summary of Teacher Responses to Question about Lesson Plan Content

	N	**%**
GABI	8	23%
Cone Shell Inquiry/Gatun	7	20%
Horse Tooth Lesson/Evolution	7	20%
Megalodon jaw reconstruction	4	11%
Megalodon total body length	4	11%
Life of a Fossil	3	9%
Becoming a scientist	2	6%
Geologic Time Scale	2	6%
Geomorphological processes	2	6%
Micro-Fossils	2	6%
Ocean Currents	2	6%
Plate tectonics	2	6%
Science literacy	2	6%
What is a fossil	2	6%
Adaptations	1	3%
Continental drift	1	3%
Echinoderm Design	1	3%
Fossil history of Florida	1	3%
Mammal vs reptile skulls	1	3%
Megalodon extinction	1	3%
Recreating a Chadronian Food Web	1	3%
Re-introducing Sea Otters	1	3%
Sorting and identifying Gatun Fossils	1	3%
Text-rendering lesson	1	3%
Titanoboa Climate Change	1	3%
Titanoboa total length	1	3%
Timeline of Human Evolution	1	3%

G. Educator Lesson Plan Summary

During the summit, the 22 educators in attendance were asked to present on one or more of the lessons they developed that were based on their GABI RET experience. The teachers prepared a brief presentation that contained information about the topic, the grades it was prepared for or used with, and any additional information they felt was important about their lesson. Teachers consistently talked about the collaborations with both other teachers and the scientists from the GABI RET program, using their experiences to "hook" the students and engage them, and the NGSS and other standards they included.

An analysis of 22 lesson plans showed: 1) Teachers were able to integrate the scientific content of their RET experience into their curricula, 2) The authentic field experience gave them a way to engage students in research practices, provide a real-world context for classroom work from their own experience, and to have credibility as researchers with their students, 3) Teachers demonstrated and reported being more knowledgeable about paleontology content, methods, and careers to share with their students.

Topic	Grade(s)	Notes
Carcharocles Megalodon Study	5 Bio classes High School students	• Developed a meg jaw • Using Paleo as a hook for their entire year and major theme • Stations to incorporate scientific processes. Journals, drawing, measurements, research, etc. • Incorporated art into the lesson when coloring the teeth • Collaborated with a colleague to refine the lesson • Developed an info sheet to share with the public and visitors to the school
History of Earth Timeline Activity	10th grade biology 1hour 50-minute time block	• Collaborated with a colleague from a neighboring school • Web based lesson • Introduction to evaluation • Utilized web resources to develop and expand lesson • Created changes for the next class including fossils and 3D printing
Snail Shells: The hole truth and Nothing but the truth	2-week unit 7th grade	• 5E Model unit • Engaged with a memory prompt • Explore – went to local beach to look for and collect fossils – include a reflection on the process and predictions – included graphing and collaborated with a math teacher. Scientific prediction about their shells with holes • Explain – Where did the holes come from and why are they there • Extend/Elaborate – look up other predator-prey interactions

		• Evaluate – Developed wanted poster for the cone snail. Differentiated evaluation assignments in the second one being an article
GABI and Shells Chewing on Change (2nd lesson) Prehistoric Niche Project (3rd lesson)	All girls High School	• Developed a display of the shells from BAGI • Horse tooth activity – collaborated with two of the scientists and another educator. Framing the whole year around evolution. • Seen the evolution lesson develop into the students' favorite lesson for the year. • Included the Tupper talks and the argumentation • Would use the claim, evidence, reasoning method in the next iteration of the lesson. • Niche project more focused as an independent student project. • Biggest take-away is that the GABI is the common theme for the year and acts as an overarching theme for the year.
Working Like Scientists	K-12 School Project with 6th grade	• GABI gave me the tools to have a project for the first day of school. • 3 50 minute blocks for the lesson • Learning Goal – Tell what a scientist does • Stations for the project. Station 1 – asking questions. Station 2 – DIG and draw (finding fossils and then drawing them). Station 3 – Using mathematics and making qualitative observations. Station 4 – Making quantitative observations. Station 5 – Analyzing data. Station 6 – Scientific argumentation. • Working on patterns such as increase and decrease • Working by telling a scientist's story • Extension activity to look at the claim based on the short paragraphs.
How Big Was Megalodon	6 and 7 Students working on the building of the jaw did so in the art class	• Developed the lesson with two scientists (on the website) • Co-Taught lesson with Victor (scientist) to refine it • Developed three posters for conferences and now lesson is available and has been used by numerous other classrooms • Shared materials with an Australian teacher who how does the lesson with her classroom • Students then went into the field to collect meg teach and keep them • Students have started to print their own teeth • Students to take photos of fossils with a scale and be able to upload their images to the database • Collaborated with art class to build a meg jaw

		• Student developed jaw will be on display at the museum for the 100th anniversary
Dissecting "Battle for the Americas"	Middle school 1 class period (90 minutes)	• Graphic organizer associated with the lesson • Different supporting texts • Formative and summative assessment • Very engaging for the students that they "really got into" • Bruce and other scientists have talked with the students through emails. • Aligned to both NGSS and Common Core • 5 E Lesson • Lesson has defined vocabulary and clear layout • Also developed a teacher guide so that others could use it with their classes – includes templates, directions, and other tools. • Clear and direct focus on the scientific process • The connection to GABI and the scientists "made it real" for the students
Battle for the Americas	Middle School	• Aspects – review battle of the Americas, started field journals, and the path of a parasite unit. • Talked live with Bruce through a webinar • In journals, students included fossil drawings and descriptions. • Live Skype with Dr. Guzeman to talk about Parasites and the path. • Also did the peach river field trip to collect fossils (40 parents and students) • Gatun Formation and connection to Florida in their journals. • Validity in the classroom, credibility as a teacher, extended interest, collaborations, colleagues, and recognition of local environment.
Biodiversity Plaques	High School Environmental Science Working with ELL and SPED students	• Reading scientific articles – condensed it into a graphic organizer. • BioMuseo – desire to develop a similar display for their school • Accessed the GABI RET website to find the lesson developed by another teacher to elaborate on it for her school • Looking to collaborate with the art teacher in the school for a future project. • Panama lesson plan – collaborated with another teacher • Student outcomes – asking questions, collaborating, comparing and developing a model with evidence.

		• Using evidence to corroborate and dispute models. Use Kinsella's 4Ls and Fisher and Fray's helping curriculum. • Activity included building background, skyping with scientists, collaborate in groups of 4 to work through the databases, and report out through presentation. Finally develop a justification independently. • All resources available on a shared Google drive • Wants to collect additional evidence of learning.
PIRE and GABI: An Educator's Journey	7th grade	• Authentic paleontology field experience • Built extensive content knowledge • Development of a professional community • Classroom translation – high quality lessons, collaboration, support, authentic science. • Museum opening – attended by administration, school students, teachers, press. • Incorporated visiting scientists and colleagues • Engaging experiential learning environment for the students ("young scientists")
Honors Biology Fossil Jigsaw and GABI wall display	High School Regular biology students (inclusive)	• Collaboration with another teacher to develop lessons • Jigsaw – 1 class period – get students to use observation skills and research • GABI Wall display – up to 4 50-minute class periods • Inspired by the Biomuseo display – develop biocards • Incorporates research, art, standards – linking to environmental change
An exploration of moon snails' predator pray relationship	9th grade biology students of all levels	• Inspired by the WATCH program through the Monterrey Aquarium • Building on student background • Lesson to take 6-8 class hours – looking to incorporate 3D printing – based on 5E lesson design • Resources from Gatun fossil guide, articles, fossils, modern specimens • Involved in observations, research, analysis, supporting claims, presenting. • Students working collaboratively • Assessment – summative – poster display, formative – ongoing assessment from collaborations and achievement levels. • Students working with data from their exploration of the shells and analyzing the data to make a prediction. • Final presentation with a gallery walk. Present with a poster board, imbed pear review, discuss with attendees.
Taking enthusiasm to	Elementary School	• Getting students to a local beach to collect fossils and get excited

translate to a classroom	3rd grade	• Incorporate hands-on activities • Use of classroom replicas for students to research and touch • Using real scientific questions • Students being introduced to scientific process and units of measure • Mammal skulls vs Reptile skulls • Adaptation process – incorporated megalodon jaw activity • Follow-up activity – students taught younger students about sharks and adaptation • Students Skyped with a scientists and asked questions • Students were most excited about science at the end of the year
Using stratigraphy, core modeling, and 3D printing to discuss ocean change over time "Coring is a piece of cake"	High School Advanced science	• How to integrate paleo into an advanced science class • Studying foraminifera • Identifying the significance of Forams • Collaborations with project scientists • Wrote sample coring activity • One class period • Made two layer cakes, teacher key, lesson plan • Developing a second lesson plan with another project teacher. Incorporating an international 3D database of Forma to download and print. • Will use small printed models and place them into different drawers of the clear file boxes • Possible extensions – looking at other fossil strata, ocean cores, teaching about climate change.
GABI	Middle School – 6th grade	• Collaborations with local and regional teachers • Collaborations with project scientists • Invited presenters for the classroom • Working with the students to formulate scientific questions to ask a scientist • Using tools of the scientists • Further activities with scientists in the field • Invited scientists to talk to whole school (6-8th grade) • Was a teacher leader prior to the new cohort going to Panama • Active in the process of scientific investigation • Media coverage of their experience and findings • Students developed questions during the sand dollar lesson • Iterative process of asking questions and building, learning, and changing

		• Lots of projects coming along including micro fossils, 3D printing, and mathematics
GABI	High School 10-12th grades	• Students working on the project for 4 weeks – both in and out of the classroom • Students started learning about the formation of the isthmus • Q – how were the animals affected by the formation of the isthmus • Students explaining the migration, conducting research, working and collaborating with others, reading scientific journals, a graphic organizer, and summarizing. • Process – watch the video, read articles, worked in groups, presented to the class. • Lesson incorporated many different learning styles, were engaged, and loved the 3D printing • Found some of the content difficult and findings 3D images of the animal they wanted to print • Changes – reducing the focus to more paleo and less on the GABI
Looking for Microfossils	8th grade teacher and now High School chemistry teacher	• Based on the discovery of interest in microfossils • Incorporating field experiences, being teacher as scientists, inviting quest speakers, redesigning courses, adding PBL, integrating technology, developing STEAM, showing how scientists work • Developed a 4-6-week unit on being a scientists and scientific practices based on the GABI experience • Importance of seeing teacher as "real scientists" • Invited speakers and scientists • Interested both the students and their parents – opportunity for the students to teach their parents • Incorporation of NGSS and inquiry as a model for learning • Looking into connecting through STEAM • Integrating technology • Using science principles to help develop district Science Practices and Curriculum • Focus on authentic learning
Translating NGSS into Instruction	PD for teachers	• Working with teachers to help them incorporate NGSS into their classroom and curriculum • Working to construct a common understanding of what students need to learn • Helping teachers draw out the questions from their students • Facilitating learning

		• Focused on the why and allowing questions to drive the investigation • Building from essential questions

H. 2014 – 2016 Field Practices

To illustrate how teachers transferred their experiences from the field directly into classroom experiences for their students, we have listed field practices and activities that the teachers participated in while in Panama and listed the classroom practices developed from the many experiences. This data was collected from the teachers' descriptions of their classroom practice and compared with the field practices listed on the GABI RET website.

The teachers drew directly from their field experiences to develop classroom practices to be used with their students, as embedded practice, and as part of their lessons. The field experiences can be divided into four areas: (1) Fieldwork, (2) Paleo-Talks, (3) Articles/Papers, and (4) Tupper Seminars. From each of these areas, the teachers developed translated what they had learned into meaningful practices in their teaching. For example, a type of field work was collecting and assembling kits. One teacher wrote about turning this into a best practice in her classroom where the students were responsible for gathering all of the necessary laboratory equipment for their work. Other teachers wrote about the content they learned as part of the Paleo-Talks they heard while in Panama. They translated what they learned into lessons for their students designed to help them better understand the complex nature of the GABI.

Field Practices in Panama	Classroom Practices Developed from Experience
Field Work	
Collecting kits assembly	• Gathering equipment for lab work
Playa Veracruz to collect modern shells (Gatun lesson planning)	• Fossil collection field experiences • Using fossils to collect additional data and ask questions, draw conclusions • Recreate digs • Immersion in the scientific process
Discussion about geology and fossils of Lake Alajuela	• Sketching ecosystems • Inquiry based exercises • Evidence to support claims
BioMuseo for lesson development	• Museum exploration • Real-world based lesson development
Poolside chat (Pool-side chats are daily discussions, by the pool, about the activities of the day and the logistics and plans for the next day. Great place for brainstorming new ideas or for reflections.)	• Student group discussions, problem solving, collaborations • Asking questions from the perspective of a scientist • Critically analyzing data • Offering personal stories • Sharing photos • Shared experience

Paleo –Talks	
Late Miocene rodents and sharks from Lago Bayano, Panama Province	• Great white shark natural history
From ocean gateway closure to land bridge exposure: Insights from Caribbean paleoceanography by Dr. Amanda Waite.	• Ecology and Evolution on and the Isthmus of Panama
“A half-century of discovering Miocene vertebrates from Lake Alahuela: Past, present, and future” by Bruce MacFadden	• Fossil history of Florida • Panama Canal Change Over Time: How the Canal Works Lesson

Articles/Papers	
Integrated chronology, flora and faunas, and paleoecology of the Alajuela Formation, late Miocene of Panama	• Picturing flora and fauna that would exist in that environment
Battle for the Americas and Middle Miocene closure of the Central American Seaway.	• Geomorphology and Landform Creation • Geologic Time Scale
Glowing Seashells: Diversity of Fossilized Coloration Patterns on Coral Reef-Associated Cone Snail (Gastropoda: Conidae) Shells from the Neogene of the Dominican Republic	• Using shell fossils brought back from Panama • Killer Cone Snails - adaptations • How do scientists develop artistic representations of species based on fossils
Ancient Nursery Area for the Extinct Giant Shark Megalodon from the Miocene of Panama	• Megalodon total body length lesson • Megalodon jaw recreation • Why and how the Megalodon went extinct
Quaternary glaciation and the Great American Biotic Interchange.	• Geomorphological processes
Sigmodontine rodents diversified in South America prior to the complete rise of the Panamanian Isthmus	• Plate tectonic lesson/climate change lesson that includes closing of isthmus
Paleobiogeografía del arribo de mamíferos suramericanos al sur de América Central de previo al Gran Intercambio Biótico Americano: un vistazo al GABI en América Central.	• The emergence of new species overtime • Comparing marine fauna from the Gatun Formation to post-closure California marine fauna
Using Fossil Teeth to Study the Evolution of Horses in Response to a Changing Climate.	• Horse tooth evolution inquiry lab • NGSS 3D Learning with Fossil Horse Teeth Teacher Professional Development • Horse tooth evolution as habitats changed from forests to grasslands
Spatial and Stratigraphic Variation of Marine Paleo environments in the Middle-Upper Miocene Gatun Formation, Isthmus of Panama. Hendy, 2013	• Relative Dating and Superposition • Continental Drift Plate Tectonics • Geological time period
Battle for the Americas. Stone, 2013.	• Culture, determine values

Gomphothere proboscidean (Gomphotherium) from the late Neogene of Panama. MacFadden et al., 2015.	• Gatun Fossil ID • Connected the phenotypic differences of Gatun fossils to hypothetical genotypic differences
The closure history of the Central American seaway: evidence from isotopes and fossils to models and molecules. Schmidt, 2007.	• Mammal vs reptile skulls- adaptations • Panama Canal Change Over Time: Building the Canal Unit
Glowing Seashells: Diversity of Fossilized Coloration Patterns on Coral Reef-Associated Cone Snail (Gastropoda: Conidae) Shells from the Neogene of the Dominican Republic. Hendricks, 2015. OPEN ACCESS.	• Micro-Fossils: classifying and sorting • Mollusk fossil examination, identification and interpretation

Tupper Seminars	
The Great American Biotic Interchange (GABI) and dispersal of the horse Equus into South America by Bruce MacFadden	• Chewing on Change - students explore evolution through an inquiry based lesson on fossilized horse teeth • 3D horse teeth
Which animals did the pre-Spanish Native American villagers of central Panama represent on their art, and why? By Dr. Richard Cooke	• GABI movement of terrestrial animals between N & S America
Fossil Lianas and the History of Miocene Rainforests in Panama by Nathan A Jud	• Titanoboa Climate Change
Why there are so many kinds of tropical trees? A historical perspective Egbert G. Leigh, Jr., STRI	• Fossil Unit- How are fossils formed? What is a paleontologist?

I. Community Network Analysis
For the educators that attended the summit, they reported a total of 57 connections with other program teachers averaging 3.4 connections each. The range of connections was from one to seven connections. The teachers also reported a total of 67 connections with the 15 program scientists averaging 3.9 connections each.

For the teachers, developing their social network was directly linked to their confidence and the likeliness that they would collaborate with another teacher when developing a lesson based on the GABI RET experience. When talking about the development of their professional network through the project, the teachers also frequently commented on the impact of networking with the project scientists had on them and their students. The teachers reported that they planned to continue to collaborate with each other and the project scientists. The scientists seconded this idea and reported that they not only enjoyed working with the teachers and their students but looked forward to continuing that relationship beyond the project and expanding it where possible.

J. Impact on Teachers' Knowledge

Teachers were asked to complete an eight-question knowledge test about key concepts associated with the GABI and the teachers experience as part of the Teacher Practice and Effects Survey. A total of 35 of the program teachers completed the questions. The knowledge questions were another method developed to address the first research questions, *In what ways did working with scientists on an ongoing research project affect the teachers?*

A scoring rubric was developed and used by two of the project staff to score the anonymous teacher responses independently. Scored responses were compared across items and for overall score. After analyzing the overall scores, we found a discrepancy between scores for one of the eight items. Through discussion, it was determined that the item was not a good question. Based on the teacher responses and the range of responses given the question was not clear. The item was not used here and will be revised for future use.

Content Questions

1. When did the Isthmus of Panama close completely?
2. What is the geological epoch name for the age of the Gatun fossil localities?
3. How were fossil marine faunas affected by the final closure of the Isthmus?
4. Give three examples of animals that lived in Panama in the past, but are extinct there now.
5. How can land mammals and marine animals be found in the same fossil locality?
6. Which of the following animals migrated from North to South America during the Great American Biotic Interchange? (circle all the correct responses)
    a. horses
    b. sloths
    c. monkeys
    d. armadillos
    e. rhinoceroses
    f. camels
7. Why do paleontologists wash sediments through screens?
8. Briefly describe how the Biomuseo interprets science content that pertains to paleontology.

The reviewer summed the scores to give each teacher a total score. The summed scores were then compared statistically to determine their reliability of scoring.

Educator Scores by Project Staff

Teacher	Rater 1	Rater 2		Teacher	Rater 1	Rater 2
1	6.5	8		19	17	18
2	17	18		20	18	17
3	17	18		21	14	18
4	17	15		22	19	19
5	10	12		23	20	19
6	13	19		24	19	18
7	16	16		25	12	15

8	16	16		26	13	15
9	12	18		27	16	15
10	17	18		28	19	19
11	18	19		29	10	14
12	18	18		30	11	10
13	18	19		31	20	21
14	18	20		32	18	19
15	15	15		33	17	15
16	17	17		34	17	12
17	17	16		35	15	17
18	21	21				

Teacher Score Summary by Rater

	Rater 1	**Rater 2**
Mean score	16.0	16.7
SD	3.25	2.92
t-test		0.33

Out of a possible 21 points, the teachers averaged a score of 16.3 (78% correct) with a standard deviation of 3.1, a min score of 6.5 and a max score of 21. These results show that teachers learned the content associated with the research and necessary for developing lessons and accurately guiding the students.

How have you incorporated STEM careers into your classroom based on what you learned and your GABI experience? *(Focus group)*
When asked to describe how they had incorporated STEM careers into their classroom, the GABI teachers reported having the invited scientists talk to the students directly about careers, presenting about "sub-careers" (related careers) and the outlook for those types of jobs and what types of experience are necessary, being explicit about career connections when they talk to their students, having their students write letters to scientists in a variety of fields, and discussing how the changing nature of the field may affect the students in the future.

Teaches reported that their students were affected by STEM career exposure. They shared how the scientists had emailed their students back when they asked questions and emphasized how the mentors talked about the science classes they had taken, that at least one student included their experiences in their college application, and the feedback they received from parents about how their child had gone on to be a science major because of their experience.

> *I've taught 2 generations – I get parents through Facebook who have contacted me to say – my son just entered forestry school because of your class.*

K. Impact on Scientist Mentors
To develop an understanding of the impacts of being part of the GABI RET project, we surveyed the mentors and asked them to participate in focus groups while attending the summit. The questions were designed to provide data on our two research questions:
In what ways did working with the teachers on their research project affect the scientists?

The Mentor Survey asked them to identify the ways in which they were affected (STEM identity, understanding of the nature of science, practicing science) and what about the nature of the experience caused those effects (international, immersion, working with teachers, sharing science and practice).

In what ways did the research experience affect scientists' practice?
In the focus groups, mentors were asked about how the effects identified translated into changes in their practice and how they now view the importance of exposing teachers to science, the nature of science, how they practice science, and their role as scientists.

Summary by Research Question
Research Question 1: In what ways did working with the teachers on their research project affect the scientist mentors?

Did your understanding of teaching and learning change as a result of working with your teacher partners? If so, how? *(Focus group)*
All of the scientists reported that working with the teachers changed their understanding of teaching and learning. The scientists wrote about learning how to develop lesson plans and incorporating standards, how to make learning fun and engaging, the importance of classroom management, and the different opportunities for learning. The scientists also wrote about enjoying the excitement the teachers brought with them into the field.

Scientist Responses

- *Yes. I learned how lesson plans were created, the standards they had to adhere to and how to explain a complicated subject to someone with no or very little prior knowledge on the topic and make it fun, engaging and learn from it.*
- *Yes, I became more aware of the importance of classroom management and teaching to learning standards, such as NGSS and Florida's Sunshine State Standards.*
- *Certainly. I think the most obvious example of this is how crucial class management is to achieving learning outcomes which I learned when spending time in classrooms. Additionally, it became apparent that students respond best when a subject is approached with energy and charisma and even more so if the teacher builds close bonds with each student individually.*
- *Yes, I was able to see how teachers create lessons according to current scientific standards. I had previously not had much experience in the planning of these lessons.*
- *Yes. As a scientist, I did not have much experience in understanding how/what K12 educators need for meaningful collaboration.*
- *My experience as a GABI-RET intern was instrumental in shaping my future educational endeavors. As an intern, I was put in a unique position allowing me not only to learn a*

tremendous amount from Post Doc, PhD and M.S. students but also from K12 educators. My field experience in Panama was directly applied to curriculum formulated and implemented in the classrooms of these GABI-RET teachers. Being a part of the educational process, from field excavation to the classroom setting allowed me to observe firsthand the necessity of experienced science educators. Often scientific research is linguistically tailored to experts and thus its broader implications and significance is lost in translation. GABI-RET is pioneering teaching experiences that allow not only K12 teachers but also scientists, like myself, to become better learners and communicators through collaboration thus producing more effective scientist/educators. I personally attribute my academic aspirations to my experiences with University of Florida's PCP-PIRE and GABI-RET projects.

- *Yes, attending the meetings where we worked with the teachers to develop lesson plans improved my understanding of the time and energy that goes into lesson development.*
- *Absolutely- I am now much more aware of the opportunities and limitations associated with teaching at the K-12 level, as well as the power of engagement through interactions with the scientific community and hands on field based learning.*
- *Definitely, I am primarily a museum curator/ researcher and do very little teaching at any level, but mostly college not K-12. It was great working in the field with the middle and high school science teachers and experiencing their excitement to learn new things. I suppose the most important thing I learned was how important field and hands-on experiences are to teaching.*
- *My opportunities to learn from the teachers while in Panama was limited since the majority of their discussions occurred without the presence of the interns. When we were with the teachers, it was use teaching them about what we had learned thus far during our time in Panama. I wish my cohort of interns had been able to work with the teachers more so that we could have learned WITH them as they shared ideas amongst themselves at their nightly meetings.*
- *Yes, I would say that my understanding of teaching and learning changed as a result of the GABI-RET program. Mostly, this is due to learning how teachers incorporated (and/or planned to incorporate moving forward) hands-on science experience into their classrooms in a wide variety of subjects.*
- *Yes, I learned a lot about the challenges/constraints/freedoms of the classroom, and how teaching STEM topics can be hindered or helped by them. As a teacher now, I understand the many factors that influence teaching paleontology successfully.*

If you had an opportunity to visit a classroom, how did your visit impact you? If you visited more than once, how did your visits change over time? *(Focus group)*

Eleven of the 15 mentors (73%) had an opportunity to visit a classroom – in-person or virtually. Most of those mentors visited more than one classroom or on class multiple times with one scientist visiting nearly all of the teachers' classroom at some point. The scientists were pleasantly surprised by the level of engagement and excitement of the students as well as the types of questions they asked. From their teaching experiences, the scientist began to think about teaching in both formal and informal settings, changed their understanding of how to work well with students, how to best communicate with them and convey their ideas and findings, and the impact of the GABI RET experience on the teachers and their classes.

For the mentors that had the opportunity to visit a classroom more than once, they reported that, over time, they became more comfortable working with the students, were able to better communicate their ideas and answer the students' questions. For one mentor (a graduate student), the numerous classroom visits actually changed his intended career direction going from researched focused to education: *After the first few classroom visits, I became far more interested in science education that I was before and led to my decision to pursue a PhD to merge scientific research with science education/outreach.*

> *"Interacting with students in the classroom helped me realize that I want K12 teaching to be a large component of my career."*

Mentor Responses

- *I did a skype visit with a 3rd grade classroom. I was surprised by the level of questions being asked. The questions were much more sophisticated than I expected from 3rd graders. I realized that I had misconceptions about what elementary school students already knew about science, ecology and animal behavior. I did not get a chance to visit with the same class again.*
- *Interacting with students in the classroom helped me realize that I want K12 teaching to be a large component of my career. However, after multiple classroom visits I felt that I would prefer teaching in an informal setting, such as a museum.*
- *I have been fortunate to have visited classrooms often over the past three years. These visits immediately had a strong impact on me in that they changed my career outlook. After the first few classroom visits, I became far more interested in science education that I was before and led to my decision to pursue a PhD to merge scientific research with science education/outreach. Over the course of my classroom visits, I became far more comfortable speaking in a public setting (including at conferences and during presentations for colleagues), but I also learned to become a more effective educator. For example, I became more familiar with which types of questions elicited the best responses from students and higher order thinking and how to more effectively implement hands-on activities.*
- *I really enjoyed sharing my knowledge and perspective regarding my journey as a paleontologist. It was great to see students excited about science!*
- *The visits were amazing! Over the course of multiple visits, I got to understand my audience better and tailored my speeches to be about what they wanted to hear, not just what I thought they wanted to hear*
- *After my PCP-PIRE/GABI-RET internship, I worked with three different teachers planning classroom visits. Being in the classrooms helped me see the GABI-RET's influence from a different angle. The first visit I had was very focused on the work I did in the field with a secondary focus on what the students' teacher did during and post Panama. After being in this classroom, it became evident that a few alterations on how the information was delivered need to take effect. The last two classrooms were full of the same content but semi-guided by the students' questions and interest. Overall, this allowed the teacher and me to deliver more information than originally planned all the while engaging the students. The evolution of my classroom visits helped provoke*

original questions and ideas amongst the students that we did not initially plan for during our workshops therefore allowing for quality classroom involvement and participation.

- *I only visited a few classrooms during my association with the GABI RET project, several in California and several in Florida. I was amazed at how incredibly bright the students were, at both the middle and high school level, in both CA and Panama. My fellow students and I were much "dumber" back in the day (no computers, no internet back in the 1960s). It is hard to evaluate how my visits changed, because each class visit was incredibly different.*
- *I visited teachers' classrooms through video conferencing; it was a wonderful experience to share my research with students, as well as to answer their questions about my research.*
- *Sadly, I did not have the opportunity to visit a classroom or work with a class at any point. My fellow mentors did have the opportunity to go out in the field with the teachers and a classroom of students from Panama. There was not enough room for all three mentors.*
- *It impacted me deeply, but hard to put it in words. It was just a very rewarding experience as I could see excitement on students and real-time change of perceptions.*
- *I never visited a classroom but I did do two Skype presentations to a Second Grade science class. Having the opportunity to interact with the children and see their excitement for science was quite motivational. I really am living the dream!*

On this project, what benefits have you had from working with the educators? *(Focus group)*

- 100% of the scientists reported that they had visited a classroom or had the students come to them
- Many of the scientists reported being interested in teaching and working with students
- The scientists reported gaining valuable experience with presentation and communication skills

The scientists also talked about being role models for the students, considering their work in a broader context, and learning to work with and engage students in and out of the classroom.

> "All of us have some level of interest in teaching, but don't often get any training on how to teach. Working with the teachers, and visiting their classrooms has taught me more about teaching than I ever got as a TA."

Research Question 2: In what ways did the research experience affect scientists' practice?

Explain how working with teachers on the Panama project influenced your implementation of the scientific process in your own work. *(Focus group)*

Working with the teachers as part of the Panama project had a profound impact on the scientists' own practice. When asked about the influence working with teachers had on their own work, the scientists wrote about insuring their own work was more clearly explained and accessible, changed in their "end goal" for their work, and considering the broader impact of their work. A number of the scientists wrote about changes in their ability to communicate their work. Communication is something that scientists are continually challenged with and ways to help them become better communicators are always welcome. The scientists also wrote about involving teachers more in their research, how to translate their scientific work into classroom activities, the broader impacts of their work, and changes to their scientific writing style.

Scientist Responses

- *Now knowing the requirements needed to create a lesson, I approach my work differently. I still adhere to the same scientific process as before but I make sure that my methods are explained clearly and that there is no ambiguity in my results and explanations. I want my research to be accessible not just to colleagues but also to people outside of my career.*
- *I no longer consider a publication in a peer-reviewed journal as the end goal for a research project. Now I see it as a classroom lesson. I strongly believe that any research project can be translated into a K12 lesson.*
- *I'm not sure it directly changed how I approach my scientific work, outside of science education. However, it opened doors that allowed me to collaborate with teachers and science education faculty to publish on education research related to the Panama project. Additionally, I see more clearly the importance of science communication and translating our research findings to the general public for dissemination in numerous venues (e.g., schools, informal education settings, etc.).*
- *I think that working with teachers has helped me learn how to communicate science to people in a more clear and concise way. Talking with the teachers allowed me to see how most people view and interpret scientific principles, which is important to know when explaining science to the public.*
- *Looking at science from an outside perspective*
- *Working with teachers on the Panama project altered the way I form and carry out the scientific process in my personal work. Post Panama project life involved paleoanthropological/geological work in Kenya followed shortly thereafter by Fulbright Scholarship application. The Fulbright's main focus was to conduct paleo-environmental research with full immersion into a surrounding community. I took a Swahili course during this process so that I may better communicate with those I would be working with. The Panama project heavily influenced my desire to work with students in this area as a main focus accompanying the scientific research. All in all, GABI-RET has highlighted the necessity for a more personal relationship between science and k12 education that guides many academic decisions I have made after my experience.*
- *I found myself considering how I might involve teachers in my own work in the future. I also now consider what types of tasks are easily transferable to a classroom setting where students could participate in data collection.*
- *I now not only feel more comfortable sharing my own research with broader audiences of all ages, but also see the necessity of doing such. Achieving impactful 'broader impacts' initiatives now seems much more attainable and I am even more comfortable/confident training others of varying levels of experience in the methods and process associated with my work.*
- *The main influence in working with the teachers is that I now think about how my scientific research might have a broader impact on the public. Before, I was mostly*

concerned about how my close circle of scientific colleagues viewed my work. During the Panama trips, the GABI RET group would read and comment on scientific papers that directly related to our paleontological field work in Panama. It was very instructive to see how the teachers understood and evaluated the scientific papers, and what aspects of the research they considered most interesting and significant.

- *Teachers assisted with collection of the fossils that I have subsequently used in my research.*
- *In this regard, I enjoyed sharing with the teachers how I implement the scientific process while in the field and lab. I also enjoyed hearing how the teachers would translate their experiences and our experience stories to fit a classroom setting. Working with the teachers, however, did not change the way I implement the scientific process but I think we illuminated what the process truly is for the teachers.*
- *Working with the teachers has not specifically influenced my implementation of the scientific process yet, but I believe it will in the future.*
- *I changed my scientific writing style to accommodate a wider audience and to hopefully be a tool to teach science writing and science concepts in the classroom.*
- *I don't think it changed my implementation of the scientific process. I did in terms of communication and outreach, and allowed me to dimension the amount of people I collaborate with in a year, and the importance of those connections.*
- *After interacting with the teachers, I think more about what lessons can be extracted from my work at each step of the process. And how those lessons can be incorporated into interactive activities based on my work. I seldom thought about the outreach part of my field until I had the chance to meet the teacher and see what they needed from the scientists in order to bring science to life in their classroom.*

What did you learn about mentoring from working with the teachers during this experience? What surprised you most about these interactions? *(Focus group)*

When asked about what they learned about mentoring from working with the teachers, the scientists shared how their perception of the relationship changed from one of mentor-mentee to mentor-mentor. The scientists felt they learned as much from the teachers as the teachers were learning from them. Their perception of mentoring changed from seeing it a one directional relationship to a two-way relationship where both parties benefit. The teachers learned skills and gained valuable field experience while the scientists observed the patients of the teachers, their passion and excitement, their willingness to learn and grow, and the importance of having hands-on experiences.

Scientist Mentor Responses (note that some mentors were part of the project as "interns")

- *I was surprised by how patient they all are and their perseverance. They understand that students require constant reminding to stay on task, not just because they are fidgety, but because they may not understand the lesson. Recognizing a loss of interest due to confusion on the topic helps teachers tailor the lessons created to match each students' abilities.*
- *My experience working with the teachers was more like a mentor-mentor relationship. I provided science content, but they provide teaching expertise. I've been surprised by how well connected many of the teachers have remained with FLMNH and their continued interest in developing new paleontology lessons.*

- *I guess I learned that scheduling is one of the most important yet difficult parts of a collaboration, especially with teachers. Given busy schedules it can be easy to fail to follow up after a conversation and never, or belatedly, see an idea or plan completely through. However, the amount of devotion and enthusiasm teachers have to working on various projects, and the hoops they are willing to jump through to bring topics of interest into the classroom in innovative ways is truly inspirational.*
- *I learned that most of the teachers were incredibly eager to learn about the way scientists gather data and interpret it. I had a great time explaining and demonstrating the research process.*
- *Mentoring is more collaboration than supervisor/employee type relationship.*
- *Working with the teachers during my Panama experience, I learned a few key qualities that makes for a quality mentor, but the most prevalent one was how much the Teachers valued growth in the field as well as ongoing learning. To elaborate, many scientists in academia are a bit old school in the fact they don't like to parse out their research and are reluctant to accept new developments if it contradicts their personal findings. This quality has helped advance science as a whole but I believe it also holds us back. This being said, the Teachers were extremely open to and excited to learn/test out various theories surrounding any given topic. This willingness to adapt and grow is something I personally admire. Without a doubt, the passion that that I witnessed amongst the teachers in my group surprised me the most! This extremely prevalent passion just proves the value of GABI-RET. Five cohorts and there is still an army of STEM Teachers longing to be part of GABI-RET.*
- *I learned that when teachers are able to participate in science, the stories and pictures they bring back to the classroom can be just as engaging to the students as if they had gone on the trip themselves. I also saw how participating improves teachers understanding of the scientific process that they are tasked with teaching.*
- *In general, that it is easier than I previously assumed it would be. My previous assumption was that it required intensive imparting of content based knowledge, but I now understand that engaging them in the process of science and or inspiring passion in them through hands on experiences that they are able to share with their students can be just as effective.*
- *I learned that the teachers are highly motivated to learn as much as possible, and to pass along this new information to their students. With one notable exception (my high school biology teacher who got me interested in natural history), I don't remember my teachers in middle and high school being that interested or motivated.*
- *The questions asked by the teachers about my research were excellent - these questions forced me to think critically about areas of my research that I did not understand well enough.*
- *There was no mentor structure present when I met the teachers. I wish there had been. Based on many of these questions, it sounds like later interns DID have the opportunity to work with the teachers and I am very happy to hear that. The bridge between educators and scientists is critical for carrying science forward.*
- *I learned how much teachers sacrifice for their students, and I was surprised to find this is true across teachers from all over the country.*

Scientists reported agreeing significantly more that working with and mentoring teachers benefitted scientists as science professionals (3.5/5 pre, 4.7/5 post), as educators (4.1, 4.9), and scientists as individuals (4.1, 4.9), that it is a benefit to teachers to have a scientist as a mentor (4.0, 4.8), and that mentors are able to communicate science concepts simply and effectively (3.5, 4.5).

Please rate the following on your level of agreement BEFORE and AFTER your Panama experience. (5=Strongly Agree, 4=Agree, 3=Neither Agree nor Disagree, 2=Disagree, 1=Strongly Disagree) (N=15)

	Before	**After**
Working with and mentoring teachers benefits scientists as science professionals (in terms of career and identity as a professional scientist).	3.5	4.5*
Working with and mentoring teachers benefits scientists as educators (in terms of attitudes toward teaching and learning as educators).	4.0	4.9*
Working with and mentoring teachers benefits scientists as individuals (in terms of fulfillment and giving back to the community).	4.0	4.9*
It is a benefit to teachers to have a scientist as a mentor.	3.9	4.7*
I am able to communicate science concepts simply and effectively (in layman's terms).	3.5	4.7*

*Indicates a significant difference pre/post ($p \leq 0.01$)

The 15 scientists reported having a total of 177 continued collaborations with the teachers involved in the project (an average of over 10 for each scientists). Two of the scientists reported having no continued collaborations except in Panama; one of the scientists reported having over 50 collaborations.

Please indicate the number of each type of continued collaboration you have had with any of the teachers.

	Total
Develop lesson plans	32
Classroom visits	78
Conference presentations (papers and/or posters)	21
Co-authored a research paper	9
Virtual lecture	11
Offered field experiences	26

The scientist strongly agreed that working with and mentoring teachers as part of this research experience enabled me to see how they benefited from our interactions (4.7/5), that they benefited from working with and mentoring teachers as part of this research experience (4.6), that their experiences in working with and mentoring teachers as part of the Panama project were positive and they would participate again in the future (4.9), that working with and mentoring teachers changed their views about the demands and needs of K-12 teachers (4.7), that they would like to work with and mentor (a) K-12 teacher(s) in the future (4.8), and that they felt it is important for students to have inquiry-based learning opportunities (4.8).

To what extent do you agree with each of the following statements about your experience as a mentor? (5=Strongly Agree, 4=Agree, 3=Neither Agree nor Disagree, 2=Disagree, 1=Strongly Disagree

	Mean
Working with and mentoring teachers as part of this research experience enabled me to see how they benefited from our interactions.	4.7
I benefited from working with and mentoring teachers as part of this research experience.	4.6
My experiences in working with and mentoring teachers as part of the Panama project were positive and I would participate again in the future.	4.9
Working with and mentoring teachers changed my views about the demands and needs of K-12 teachers.	4.7
I have better understanding of working in the classroom with K-12 students.	4.2
As a result of my participation, I have a greater interest in teaching in K-12 settings.	4.3
I would like to work with and mentor (a) K-12 teacher(s) in the future.	4.8
As a result of mentoring teachers, I gained a better understanding of how to work with students.	4.5
As a result of mentoring teachers, I gained better communication skills.	4.5
I feel it is important for teaches to have field-experiences as part of their educational training.	4.6
I feel it is important for students to have inquiry-based learning opportunities.	4.8

What works best in a field experience? What things are extra? *(Focus group)*
Most of the scientists agreed that the things that worked best in a field experience included, seeing and findings fossils, teachers seeing their fossils cataloged, the connection between the museum and findings and collecting fossils, that it is "authentic," being part of the scientific discussion, and that it appeals to a lot of different groups. The scientists reported that the field experiences were definitely engaging for the teachers, and they would like to see them involved in all facts, not just collecting.

IV. Teacher and Mentor Recommendations for Future Experiences

Both teachers and mentors attending the summit were asked to consider what their best idea for the next iteration of the GABI program would look like. Working in teams of three or four, the teachers and mentors discussed their ideas and then reported out to the rest of the group. What follows is a summary of what they reported to the group.

Teachers Ideas Summary (Focus group)
The five groups of teachers offered suggestions for developing a GABI 6 that included aspects they found most helpful:

- Continue to involve the scientists as role models and program support
- Develop a way to continue the communication between the community

- Continue to offer field experiences
- Consider different time frames – lengths of the program – for the teacher groups
- Continue to engage in authentic scientific explorations
- Combine both new educators and educators from previous experiences (between ¼ to 1/3 of the cohort)
- Find a fossil location that allows for specimens to be kept by the teachers
- Summer timeframe from 10 days to two weeks
- Look to enhance the diversity of teachers and subjects taught
- Develop a component of the program where students are able to accompany their teacher into the field

Mentor Ideas Summary (Focus group)
The three groups of mentors offered suggestions for developing a GABI 6 that included aspects from their experience they found most useful:

- More diversity of educators (regionally and subjects taught)
- Teachers from states where fossil digs occur
- Develop a cohesive story for the program and experience
- Focus on the science and engage the teachers in the discussion
- Engage teachers in professional talks and experience
- Incorporate returning teachers into the cohort and have them present their experience to the new teachers
- Find a way to allow teachers to take fossil samples back to their classroom
- 25% returning teachers
- Consider pairs of teachers from the same school
- Webinars prior to the face-to-face for sharing information, covering preliminary topics, etc.
- Track collaborations and teach teachers how to prepare a professional poster and talk

V. Conclusions

The conclusions are presented below by research question.

In what ways did working with scientists on an ongoing research project affect the teachers?
The teachers highly valued learning how paleontologists think and reason (8.5), developing ways to translate field experience into classroom activities (8.5), developing proficiency in field skills (8.4), and utilizing field experiences to develop lessons and lesson plans (8.4) and the development of social and professional relationships with peers and scientists (8.9/10). The teachers reported significant change in their knowledge of STEM careers, where to go to learn about STEM careers, and where to find resources to share with their students.

Teachers became more aware of the importance of offering students challenging learning opportunities. All of the teachers (100%) agreed or strongly agreed that it was important to have students lead others to accomplish a goal, encourage others to do their best, produce high quality work, respect the differences of their peers, help their peers, include others' perspectives when making decisions, make changes when things do not go as planned, and to manage their time wisely when working on their own.

Results from the STEBI instrument focused on changes in the teachers' personal efficacy in teaching science and teaching outcomes expectancy (belief that they can affect students) via the PSTE and STOE subscales. For our teachers, there was a significant change in both PSTE (54.3 pre, 60.4 post) and STOE (38.4 pre, 42.8 post). These results suggest that participation as a teacher in the GABI RET program resulted in significant changes in both teachers' personal efficacy and outcomes expectancy. In other words, they are more confident in teaching science and expect they can affect student learning.

Teachers demonstrated an accurate understanding of the key concepts related to the science of the project the Great American Biotic Interchange as studied through the fossil record on a test of eight key concepts.

In what ways did the effects of the research experience affect teachers' teaching?
An analysis of teacher lesson and individual causal chains show that the design was effective in preparing teachers to write lessons integrating the content and the science practices into their classrooms.

The majority of teachers (81%) reported taking what they learned from their field experience and translating it into designing and redesigning classroom lessons and developing hands-on lessons and activities (57%). Teachers reported changes in their understanding of the content and increased confidence (43%), greater interest and engagement of their students (38%), and the value of parents seeing their children being excited about their learning and classroom projects (15%). When asked how immersion in scientific practice as a result of being a GABI RET teacher evolved their classroom practice to engage students in the scientific process, all of the teachers were able to give at least one example of how it had engaged students beyond their previous successes. Most of the teachers (82%) offered more than one example, such as students asking questions, bringing in fossil finds, and doing more reading on their own.

All of the teachers (100%) described at least one way they were implementing the scientific process into their lesson planning and teaching. When asked to describe the specific content of the lesson plans they developed, the teachers named a wide variety of lessons including those covering the GABI (23%), the Gatun (20%), horse tooth and evolution (20%), Megalodon jaw reconstruction (11%), and Megalodon total body length (11%). A little more than a quarter of the teachers (29%) reported having presented information about their experience at a professional conference. The specific conferences mentioned were ISTE (12%) and NSTA (2%). All of the teachers (100%) are continuing to collaborate with at least one scientist who acted as a guide and mentor. Project teachers were overwhelmingly in agreement on the importance of offering students challenging learning opportunities. They reported significant changes in all areas pre/post GABI experience including helping students to lead others to accomplish a goal (4.3/5, 4.6/5 post), producing high quality work (4.5, 4.9), and including others' perspectives when making decisions (4.4, 4.7).

In what ways did working with the teachers on their research project affect the scientists?

All of the scientists reported that working with the teachers changed their understanding of teaching and learning. The scientists wrote about learning how lesson plans are developed, how to incorporate standards, how to make learning fun and engaging, the importance of classroom management, and creating multiple opportunities for learning. Eleven of the 15 mentors (73%) who came to the summit had an opportunity to visit a classroom, either in-person or virtually. The scientists who did not visit a classroom were either new to the program or had a role that did not have them interacting with the teachers while they were in Panama. Most of those mentors visited more than one classroom or one class multiple times with one scientist visiting nearly all of the teachers' classroom at some point. For the scientists that had the opportunity to visit a classroom more than once, they reported that, over time, they became more comfortable working with the students, were able to better communicate their ideas and answer the students' questions. For one mentor, the numerous classroom visits actually changed his intended career direction going from researched focused to education: *After the first few classroom visits, I became far more interested in science education that I was before and led to my decision to pursue a PhD to merge scientific research with science education/outreach.*

In what ways did the research experience affect scientists' practice?

Working with the teachers as part of the Panama project had an impact on the scientists' own practice. The scientists felt they learned as much from the teachers as the teachers were learning from them. Their perception of mentoring changed from seeing it a one directional relationship to a two-way relationship where both parties benefit. Scientists reported that working with and mentoring teachers benefitted scientists as science professionals (3.5/5 pre, 4.7/5 post), as educators (4.1, 4.9), and as individuals (4.1, 4.9). They report that they are more able to communicate science concepts simply and effectively as a result of mentoring (3.5, 4.5).

The 15 scientist mentors reported having a total of 177 continued collaborations with the teachers involved in the project (an average of over 10 for each scientist). Two of the scientists reported having no continued collaborations while one of the scientists reported having over 50. The scientists strongly agreed that working with and mentoring teachers as part of this research experience enabled them to see how they benefited from the interactions with teachers and students (4.6/5), that this mentoring experience was positive, that they would participate again in the future (4.8), that working with and mentoring teachers changed their views about the demands and needs of K-12 teachers (4.6), that they would like to work with and mentor (a) K-12 teacher(s) in the future (4.8), and that they felt it is important for students to have inquiry-based learning opportunities (4.8). The scientists report that they will continue to work to communicate more clearly and effectively, continue to collaborate with the project teachers and present to their classrooms, try and have teachers working on field projects, and build their network of scientists and teachers to promote their work on paleontology.

This project resulted in 10 papers published or submitted and awaiting publication to peer-reviewed journals, numerous presentations at national meetings and more than 140 lesson plans in diverse fields of biology, geology, ocean and environmental science. Results of our summative evaluation indicate significant benefit accrued back to the scientist/mentors; this observation had previously been reported in the literature (Tanner 2000), but not backed up by a validated instrument as we did. We plan to publish these results in an earth science education journal. The primary research products that are available include about 1,000 fossils catalogued in our research collections and available on-line; these also serve to enhance the NSF-funded iDigBio collection (Page et al. 2015).

Summary of Evidence by Expected Outcome

Teacher Development

Increased STEM knowledge related to GABI research focus

- Teachers were asked to complete an eight-question knowledge test about key concepts associated with the GABI and the teachers' experience. A total of 35 of the program teachers completed the questions.
- Out of a possible 21 points, the teachers' average core was 16.3 (78% correct) with a standard deviation of 3.1, a minimum score of 6.5 and a maximum score of 21.

Increased understanding of scientific practices

- Teachers' lessons show they are incorporating the scientific process in their lessons to develop students' ways of thinking and acting as scientists based on their own experience in the GABI RET. All of the teachers (100%) described at least one way they were implementing the scientific process into their lesson planning and teaching that was influenced by the GABI RET. Their examples included developing hypothesis (20%), using open-ended questions (17%), incorporating investigations and/or conducting experiments (17%), using evidence (17%), collecting and analyzing data (11%), and using Project Based and Inquiry Based Learning (11%).

Increased awareness of STEM careers

- When asked about their knowledge relating to STEM careers, the teachers reported significant changes in their knowledge of STEM careers (3.4/5 pre, 4.7/5 post), where to go to learn more about STEM careers (3.4, 4.5), where to find resources for teaching students about STEM careers (3.2, 4.5), and where to direct students or parents to find information about STEM careers (3.0, 4.1).
- More than half of the teachers reported engaging their students in a number of activities associated with 21st century skills (Partnership for 21st Century Skills, 2008) in the classroom at least half the time with 100% of the teachers using at least one skill set in each class period

Increased sense of one's self as a member of the scientific community

Personal essay on STEM teacher identity, prompts provided

- Teachers (66%) are continuing to collaborate with the scientists who acted as guides and mentors.

Increased networking with other teachers and scientists

Social network analysis pre/post retrospective

Website community of practice analysis (project staff) to include sense of community, knowledge development, and value creation

- The teachers rated the development of social and professional relationships with peers and scientists highest (8.9/10) followed by learning how paleontologists think and reason (8.5), developing ways to translate field experience into classroom activities (8.5), developing proficiency in field skills (8.4), and utilizing field experiences to develop lessons and lesson plans (8.4).

Teacher Practice

Increased confidence in teaching the research process

- When asked how immersion in practice as a result of being a GABI RET teacher evolved their classroom practice to engage students in the scientific process, all of the teachers were able to give at least one example of how it had engaged students. Most of the teachers (82%) offered more than one example.
- All of the teachers (100%) described at least one way there were implementing the scientific process into their lesson planning and teaching.
- The teachers had a mean pre-score of 54.3 on the Personal Science Teaching Efficacy Belief (PSTE) section of the STEBI (min=27, max=65, SD=8.5) and a significantly different ($p \leq 0.01$) mean post score of 60.4 (min=55, max=65, SD=3.7).
- The 35 teachers completing the survey reported developing and implementing a total of 141 lesson plans averaging four/teacher with a minimum of one and a maximum of 17. When asked to describe the specific content of the lesson plans they developed, the teachers named a wide variety of lessons including those covering the GABI (23%), the Gatun (20%), horse tooth and evolution (20%), Megalodon jaw reconstruction (11%), and Megalodon total body length (11%).
- An analysis of 22 lesson plans showed: 1) Teachers were able to integrate the scientific content of their RET experience into their curricula, 2) The authentic field experience gave them a way to engage students in research practices, provide a real-world context for classroom work from their own experience, and to have credibility as researchers with their students, 3) Teachers demonstrated and reported being more knowledgeable about paleontology content, methods, and careers to share with their students.

Increased use of inquiry science in the classroom

- The majority of teachers (81%) reported taking what they learned from their field experience and translating it into designing and redesigning classroom lessons and developing hands-on lessons and activities (57%). Teachers saw changes in their understanding of the content and increased confidence (43%), greater interest and engagement of their students (38%), and the value of parents seeing their students being excited about their learning and classroom projects (15%).
- Project teachers were overwhelmingly in agreement on the importance of offering students challenging learning opportunities. They reported significant changes in all areas pre/post GABI RET experience including helping students to lead others to accomplish a goal (4.3/5 pre, 4.6/5 post), producing high quality work (4.5, 4.9), and including others' perspectives when making decisions (4.4, 4.7).

Increased enthusiasm for teaching science

- The teachers had a mean pre-score of 38.4 on the Science Teaching Outcome Expectancy (STOE) section (min=30, max=46, SD=4.6) and a significantly different ($p \leq 0.01$) mean post score of 42.8 (min=31, max=55, SD=4.8). These scores are in-line with or higher than what other studies have reported for post experience teachers mean scores (ESI, 2014; Holden, et al., 2011; Savage, 2004). These high post experience scores reveal a high self-efficacy among the program teachers after their GABI RET experience that they attribute to their research experience.

Scientists

Increased research productivity – benefit to the project

- Scientists reported significant increases in all areas: working with and mentoring teachers benefitted scientists as science professionals (3.5/5 pre, 4.7/5 post), as educators (4.1, 4.9), working with and as individuals (4.1, 4.9), and it is a benefit to teachers to have a scientist as a mentor (4.0, 4.8).

Increased ability to communicate relevance of research to the public

- The scientists reported that they are better able to communicate science concepts simply and effectively (3.5/5 pre, 4.5/5 post).

Expanded outreach

- The 15 scientists reported having a total of 177 continued collaborations with the teachers involved in the project (an average of over 10 for each scientist). Two of the scientists reported having no continued collaborations while one of the scientists reported having over 50.

Improved mentorship skills

- The scientists felt they learned as much from the teachers as the teachers were learning from them. Their perception of mentoring changed from seeing it a one directional relationship to a two-way relationship where both parties benefit.

Increased awareness of the limitations and demands of the K12 education system

- All of the scientists reported that working with the teachers changed their understanding of teaching and learning. The scientists wrote about learning about developing lesson plans and incorporating standards, how to make learning fun and engaging, the importance of classroom management, and the opportunities for learning. The scientists also wrote about enjoying the excitement the teachers brought with them into the field.

Increased awareness of the disconnect between K12 education and higher education

- 11 of the 15 mentors (73%) had an opportunity to visit a classroom – in-person or virtually. Most of those mentors visited more than one classroom or on class multiple times with one scientist visiting nearly all of the teachers' classroom at some point.
- The scientist strongly agreed that working with and mentoring teachers as part of this research experience enabled them to see how they benefited from the interactions (4.6/5), that they benefited from working with and mentoring teachers as part of this research experience (4.6), that their experiences in working with and mentoring teachers as part of the Panama project were positive (4.8), that working with and mentoring teachers changed their views about the demands and needs of K-12 teachers (4.6), that they would like to work with and mentor K-12 teachers in the future (4.8), and that they felt it is important for students to have inquiry-based learning opportunities (4.8).

Increased awareness of age appropriate activities

- For the scientists that had the opportunity to visit a classroom more than once, they reported that, over time, they became more comfortable working with the students, were able to better communicate their ideas and answer the students' questions. For one mentor, the numerous classroom visits actually changed his intended career direction from researched focused to "After the first few classroom visits, I became far more interested in science education that I was before and that led to my decision to pursue a PhD to merge scientific research with science education/outreach."

Increased enthusiasm for research

- Working with the teachers as part of the Panama project had a strong impact on the scientists' own practice because of the enthusiasm of the teachers for the topic and having to explain what they were doing made them appreciate it as a career.

Summary

The evidence presented in this evaluation supports the claim that the GABI RET met the expectations for an NSF RET and its own project specific goals. Seventy percent of the educators demonstrated increased understanding of the science, the science practices, and related careers that they were able to translate into lessons for their classrooms. The mentoring affected the teachers' confidence and implementation and the students' interest. The mentors felt valued, learned about classroom lessons and how to work with students, and benefitted from the opportunity to discuss their research with teachers and students. Teachers and mentors both highly recommend the model as an effective way to make science more authentic in the classroom.

References

Artino, A., La Rochelle, J., Dezee, K. and Gehlbach, H. (2014). Developing questionnaires for educational research: AMEE guide No. 87. AMEE, 36, 463-474.

Berk RA, Berg J, Mortimer R, Walton-Moss B, Yeo TP. Measuring the effectiveness of faculty mentoring relationships. Acad Med. 2005;80:66-71.

Bligh J. Mentoring: an invisible support network. Med Educ. 1999; 33:2-3.

Burton, L., Mazerolle, S. (2011). Survey instrument validity part 1: principles of survey development and validation in athletic training education research. Athletic Training Educational Journal, 6(1), 27-35.

Creswell, J. W., & Plano Clark, V. L. (2011). Designing and conducting mixed methods research (2nd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Davis, H.D. & Scalice, D. (2014). Results plus rigor equals impact. Astronomy Society of the Pacific, 2013 Proceedings.

El-Deghaidy, H. (2006). An investigation of pre-service teacher's self-efficacy and self-image as a science teacher in Egypt. Asia-Pacific Forum on Science Learning and Teaching 7(2), article 2.

ESI (2014). Electronic supplemental material for chemistry research and practice. Journal of the Royal Society of Chemistry. Online http://www.rsc.org/suppdata/rp/c4/c4rp00188e/c4rp00188e1.pdf

Frechtling, J. (2010). User-Friendly Handbook for Mixed Method Evaluations. NSF. 2010.
Johnstone, B. (2002). Discourse Analysis. Oxford: Blackwell.

Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey- Science Teachers.* Raleigh, NC: Author.

Grady-Weliky T, Kettyle C, Hundert E. New light on needs in the mentor-mentee relationship. In: Wear D, Bickel J, eds. Educating for Professionalism: Creating a Culture of Humanism in Medical Education. Iowa City, IA: University of Iowa Press; 2000.

Holden, M., Groulx, J., Bloom, M., and Weinburgh, M. (2011). Assessing teachers' self-efficacy through an outdoor professional development experience. Electronic Journal of Science Education, 12(2), 1-25.

Lam, T. C. & Bengo, P. (2003). A comparison of three retrospective reporting methods of measuring change in instructional practice. *American Journal of Evaluation*. 24(1), 65-80.

Partnership for 21st Century Skills (2008). 21st Century skills, education, and competitiveness: A resource and policy guide. Retrieved online May 3, 2017 from http://www.p21.org/storage/documents/21st_century_skills_education_and_competitiveness_guide.pdf.

Pratt, C. C., McGuigan, W. M., & Katzev, A. R. (2000) Measuring program outcomes: Using retrospective pretest methodology. American Journal of Evaluation, 21(3). 341-349.

Protheroe, N. (2008). Teacher efficacy: What is it and does it matter? Principal, Retrieved on February 5, 2017 at https://www.naesp.org/resources/1/Principal/2008/M-Jp42.pdf.

Ramey-Gassert, L., Shroyer, G., and Staver, J. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. Science Education 80(3), 283-315.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teachers' science teaching efficacy belief instrument. Science Education, 74,625 -637.

Research Methods Knowledge Base. Types of reliability. Retrieved from: http://socialresearchmethods.net/kb/reltypes.php

Rodriguez-Campos, L and Rincones-Gomez, R. (2013). Collaborative evaluations: Step-by-step. Stanford, CA: Stanford University Press.

Savage, S. (2004). Revisiting the STEBI-B: Measuring Self-Efficacy in Preservice Elementary Teachers. School Science and Mathematics Association. Online http://www.redorbit.com/news/science/113599/revisiting_the_stebib_measuring_selfefficacy_in_preservice_elementary_teachers/

Schiffrin, D., Tannen, D. & Hamilton, H. E. (eds.). (2001). Handbook of Discourse Analysis. Oxford: Blackwell.

Stake, R.E. (1978). The case study method in social inquiry. Educational Researcher, 7 (2), 5-8.

Tanner, K. (2000). Evaluation of scientists-teacher partnerships: Benefits to scientist participants. NARST presentation annual conference April 29, 2000, New Orleans, LA. Retrieved online April 2017 from https://www.researchgate.net/publication/267974756_Evaluation_of_Scientist-Teacher_Partnerships_Benefits_to_Scientist_Participants

Unfried, A., Faber, M., Stanhope, D. & Wiebe, E. (2015). *The development and validation of a measure of student attitudes toward science, technology, mathematics, and engineering*. Journal of Psychoeducational Assessment. doi: 10.1177/0734282915571160

Yin, R. K. (2009). Case Study Research: Design and Methods. Thousand Oaks, CA: Sage Publications.

APPENDICES

Appendix A: Sampling of Scientist Test-Retest Open-Response Item Responses

	First Response	Second Response
Question	Did your understanding of teaching and learning change as a result of working with your teacher partners? If so, how?	
Scientist 1	*Yes. I learned how lesson plans were created, the standards they had to adhere to and how to explain a complicated subject to someone with no or very little prior knowledge on the topic and make it fun, engaging and learn from it.*	*Yes it did. I have a better understanding of how teachers plan their lessons so that they can positively affect the most students. Also, I have a better grasp on how students learn and the manner in which concepts need to be taught so as to reach as many students as possible with each lesson.*
Question	If you had an opportunity to visit a classroom, how did your visit impact you? If you visited more than once, how did your visits change over time?	
Scientist 3	*Interacting with students in the classroom helped me realize that I want K12 teaching to be a large component of my career. However, after multiple classroom visits I felt that I would prefer teaching in an informal setting, such as a museum.*	*In the classroom is where I developed my classroom management skills. I realized through multiple visits that the lessons always changed slightly, either to address issues that became apparent during previous visits or to accommodate novel questions.*
Question	Explain how working with teachers on the Panama project influenced your implementation of the scientific process in your own work.	
Scientist 6	*I found myself considering how I might involve teachers in my own work in the future. I also now consider what types of tasks are easily transferable to a classroom setting where students could participate in data collection.*	*I was encouraged by the teachers enthusiasm and I now view teachers as a source of person-power for collecting data and disseminating research results*
Question	What did you learn about mentoring from working with the teachers during this experience? What surprised you most about these interactions?	
Scientist 2	*Working with the teachers during my Panama experience, I learned a few key qualities that makes for a quality mentor, but the most prevalent one was how much the Teachers valued growth in the field as well as ongoing learning. To elaborate, many scientists in academia are a bit old school in the fact they don't like to parse out their research and are reluctant to accept new developments if it contradicts their personal findings. This quality has helped advance science as a whole but I believe it also holds us back. This being said, the Teachers were extremely open to and excited to learn/test out various theories surrounding any given topic. This willingness to adapt and grow is something I personally admire. Without a doubt, the passion that that I witnessed amongst the Teachers in my group surprised me the most! This extremely prevalent passion just proves the value of GABI-RET. Five cohorts and there is still an army of STEM Teachers longing to be part of GABI-RET.*	*Through working with the teachers, I best learned how to work with individuals from different academic strengths and improved my communication skills. Furthermore, the teachers' passion and openness to learning new and possible conflicting theories was astounding as it is not often a common characteristic in old-school scientific research.*
Question	Has working with teachers as a mentor made you a better scientist? If so, in what ways?	
Scientist 5	*Yes, it has made me more aware of how I communicate science to the public.*	*Yes, because it has helped me develop my scientific outreach skills in presentation.*
Question	What changes, if any, have you made in your work as a scientist as a result of mentoring teaches as part of the Panama experience?	
Scientist 1*	*I am new to the scientific career, meaning I am not entrenched in any particular way of doing work. Seeing teachers that have years of experience but are willing to change up their teaching style has taught me to be flexible in my own career.*	*I think about how my research can be used in the classroom and if it's easy to understand and explain.*

*Indicates a response found to be significantly different from response one to response two

Appendix B: Teacher focus group transcripts
Monday
Should field work be an integral part of science teachers' training? Yes= 21 No
Science teachers=21
Reasons
We are all responsible for teaching kids the process. If we are working in the field, we aren't bringing it authentically back to our students.
It's also very similar to other professions, if you don't have experience in the field, you're not going to be prepared. So, you have a better way of explaining things.
Gives credibility to a science teacher. "When I was digging fossils in Panama." N=21 You need that credibility, teachers are not thought of the way they used to be. Kids come into schools thinking teachers don't know much or have done much. Makes them think this guy is a little different.
It brings them closer to you. Builds trust with my 6th graders. Excited them, they were bringing things in that they were excited about. It's part of my personal narrative. I have all my kids saying, "I am scientist." Evidence - students bring objects in, share their experience. Students open up and say, "I didn't like science, but now I do" N=21
Since I've started teaching, I've wanted to be Scott since he's the most credible teacher I ever met. I put together ppts for him and he has tons of pictures of him doing things. Kids we are trying to reach have to buy into you.
Field work keeps you current – which re-inspired me and got me to remember why I chose to teach.
Modeling lifelong learning. N=21

How often do these field experiences need to happen?
Minimum – at least once a year = 21, Every 6 months =21, quarterly would be great, but not realistic could be on your own or collaborative

Staying current, curiosity vs.

Shouldn't be a requirement, having small kids – is it good?

Range of looking at fossils on the Thomas Farm in Gainesville in an afternoon, vs. a 2-week Panama experience

Maybe types of filed work, but not all fits the curriculum. Field work is good for understanding the process of coming up with answers, making mistakes

Real value for me – see it now – teachers are doing citizen science. It's given me the feeling I can really contribute. I can be a role model for how to contribute. Maybe in the future, I'm doing citizen science throughout the year with my students.

Citizen Science = 13
The idea of field work, and seeing ourselves as legitimate scientists is huge (in the lower grades). All being engaged around a topic, deciding what questions to ask, working in the field (outside

the classroom), really enriched my teaching. Who is a scientist? Who we see as scientists? Who our students and parents see as scientists? The idea that you could be in a Spanish-speaking environment doing science was amazing to them – it was absolutely new to them 4th and 5th graders forming ideas about where they can go and what is open to them. It's hard to make that real for them in the present.

The field work experience doesn't have to be reflected in elaborate in experience. There are only 3 weeks where my Panama experience fits in my curriculum. Countless opportunities where I can show a picture or tell a story. They think they are getting me off topic, but later on a test, they get something that I told them in a story. My kids' thing I have done everything, but I have done like three things – "We are learning from this well-traveled woman!" Having a narrative to share is so important to teaching students."

In a Language Arts curriculum, the intangibles of doing something out of your comfort zone – major life themes – grit, problem solving, facing challenges, resiliency, collaboration, communication, curiosity, pulling together, keep trying, ok to fail, accepting criticism, ok to fail, working with people you don't know, building trust with them, *collaboration* instead of competition, learning from each other.

Bill Rice and UCSC – says all teachers should experience discovery (through a master's degree), could be a new understanding about how data connects, discovering a fossil on the beach.

What was the impact on you professionally of this experience?
Feeling more comfortable collaboration with scientists, asking them for resources. I had them come into my classroom, giving me specimens to show my student. I didn't know how to connect that…. Oh, they won't spend the time to help me… now I feel like they are colleagues. N-21

Part of the network. We see it in them, that are enjoying it, and are interested, and they are learning from us. "I am part of GABI, working with Bruce McFadden."

Contact once a year = 21
2/yr = 20
3/yr = 14
Before vs. After, How many times?

Was feeling burned out. Propelled me to stay in teaching because people said "yes" to ideas and wanted to know what I thought.
I wanted to do more hands-on but wasn't' sure out to do it. Then I met all these people.
I'm more curious. I'm not afraid to ask questions now.
Made me think out of the box in my lesson plans. Made me think more than a book,
"Let's try this out and see what happens?
I've talked with Stephanie about space science. Adam sent me things unrelated ideas. I co-taught with someone on a non-GABI topic

Like-minded teachers that are highly motivated and want to bring great things to their kids in science.
I’m excited and spend the time to stay more current, and the kids really appreciate it. I email other teachers here and share it with my kids.
For me it’s about the content, I knew nothing, and now I am able to ask questions. Now I even push a little and evaluation. Made me more confident N-21
My scientific vocabulary – read like a science, disciplinary literacy, practice of science reading, discourse, writing- doing all that reading, poolside chats where you had to contribute. Have translated into teaching – being more attuned to what it takes to write scientifically, Bruce’s podcast on field journals –using more scientific practices

N=11 Tupper talks – scientists disagreeing passionately, laugh. Had been practicing, aim, argumentation, evidence in my classroom – help students to realize they could be wrong. How does your evidence back your claim?
We do peer article review – holes in the methodology they used – have students disagree.

Cohort 4 Amada Wade, rise of Isthmus 20 million years ago, Carlos disagrees. Amanda was an academic street fighter. She used ocean core sediments. I tell my students this story. Science is not this easy cut and dried thing. Other areas, scientists go at it. Kids don't’ get the idea that there is ongoing discourse, students love hearing about this. These are people who want to know the truth, not who’s right and who is wrong. This is the best supporting evidence. They are all working with the same data, they are interpreting it differently. They can’t both be right. It’s like Bruce asks us questions and he just wants us to debate it.

What were the biggest challenges of the field experience? 76% of you had done before
Went twice, participant and teacher leader. 1st field experience was great, second group dynamic was not as good (bigger, CA and FL clicks). Some teachers felt they weren’t getting anything out of it. Second group – some people not open-minded and adventurous, starting shutting down, others were just ready to go. Pre-education maybe would have helped – cultural – had pre-seminars – don’t know why chose to go. Maybe a little more pre – most were interviewed and recommended. Meet your roommate ahead of time and others (exhausting to meet everyone) A mixer would have been goo – all arrived at different times. 1st dinner - couldn’t all eat or travel together.

Didn’t know how to read the articles - hard because other people felt knew to read the articles. More time for reading, or fewer articles. More selective, hints on how to read them, needed graphic organizer – we were doing that on our own, vocabulary (supporting materials ahead of time). How to prepare for these poolside conversations.
Fewer articles N=20
How do we help our students understand the material – we were doing activities that we could do with our students. This could be our give back to grad students – **need to elevate the teaching to the level of the science**.

Cohort 3 = 10 teachers, traveled in one van
Cohort 4 = 2 vans, 25 people, didn’t even go to dinner together, tight schedule

Cohort 5 = 3 vans, 27 people, the more people, more likely to have problems, but everyone was great

Have designated groups that change – the assumption is that as adults we can do this, but we tend to self-segregate. You have to have icebreakers.

Claudia emailed link to "how to read scientific articles" I prefer hard copies. They also assigned 2 people to read and article and comment on it.

I found it difficult to be doing tasks that didn't relate to my classroom. create an NGSS lesson on these fossils (what you won't have). Cohort 5 didn't do that – it was whatever beneficial to the museum.

Constant discussion that caused it to evolve… been a moving target…

Come back to - Who pays for what?

Tuesday
How have you incorporated STEM careers into your classroom based on what you learned and your GABI experience?

Whenever we have anyone come in or come in virtually, we have them talk about their career. I had never done that before.
All the grade students have been in. I make sure that they talk about how much they read, write and do math.
We talk about sub careers. We found a website that you can put in a career and it tells you the prep, outlook.
I had 3 paleontologists. I started teaching the practices – all scientists do this – different scientists use it them to different degrees. For all the people, I introduce (mainly through video), we talk about the practices they use. The kinds of practices.
Latina role model. Prosthesis speaker, Mars rover NASA person – felt more comfortable contacting scientists in general.
Read Battle of Americas, kids didn't know who paleontologists, oceanographers, other types of scientists.
I felt like I had an intro, "I just did this field experience, and I was hoping you can…"
I do an activity that I added to after doing GABI – wrote letters to scientists in different fields – invited them to join my Wall of Fame. First person I got was Jane Goodall, EO Wilson, Norman Borlag – Jimmy Buffet started Save the Manatee, Carl Heisen. Ask them send me a picture and an artifact. Shark Attack file guy sent a jaw

At primary level, I'm very conscious that a lot of fields didn't exist 5-6 years ago. You can choose to work in something that you are passionate about, particularly if they look like them and speak their language. We doing running projects – kids choose a writing project, make a research plan, who has this kind of knowledge? Who would care? People are receptive to the kids making contacts. Monterrey Aquarium gave them a behind the scenes tour about otters –

dietician, manager, jobs evolved. Worked with Elkhorn Slough foundation, worked with biologist (who is also an actress). Common denominator is that you have to get education – being a good scientist means being a good student. By age 9-10, kids start making decisions about what they think they can do.

Do you think this exposure to STEM careers has affected them?

What evidence do you have of that?
Emails and letters from kids back, about programs they have entered because of the science they learned
I've taught 2 generations – I get parents through Facebook who have contacted me to say – my son just entered forestry school because of your class.
Student wrote his application letter to Yale, he saw Cataina - Megaladon researcher (y2 and 3)
Chris Carlson (y2) had student Sage did all the fossil stuff, paid for him to go out – went to Panama.

Appendix C: Scientist mentor focus group transcripts
Monday
On this project, what benefits have you had from working with the educators?

- *All of us have some level of interest in teaching, but don't often get any training on how to teach. Working with the teachers, and visiting their classrooms has taught me more about teaching than I ever got as a TA.*
- *Who is the mentor here?*
- *It's mutually beneficial. A lot of things are very targeted. When I visited with Megan, Adam and Myra, let me be in front of those kids. It's not streamlined, you play off what the students want to learn.*

N=7 went to classrooms or they can to you.

- *I was much more interested in spending time in classrooms. Within months I improved my K12 teaching and communication skills.*
- *It forces you to be more in-depth, explain in greater detail.*
- *My experience with this has becoming a better science communicator. In terms of classroom visits, I went as a role model (Latina role model). This is what it is like to be a scientist, here are the things you can go into it).*
- *Went to talk about how we use 3D modeling. I was a Latino role model at the conference. Working with the teachers helped me communicate better.*
- *We are recognizing what will engage the students… so they don't get wild and crazy – translates into your ability to engage your peers.*
- *Learned to align to standards. Before this, I assumed all states worked on the same standards. I created a lesson, then worked with a teacher on it, they added the standards and elevated the lesson (spend more time here), use groups here).*
- *Communication – thinking more broadly about why I'm spending money and time on this… Why would it matter to people at large? I wanted to a project that would connect to other people.*

- *Tailoring it to other subjects (LA, art, math). Before GABI – carving bones to an art classroom. Hearing how the teachers tailored it to their classrooms, helped me to learn how to tailor things going forward.*

What works best in a field experience? What things are extra?

- *Popular – we go to a field site, see fossils, then go to a museum, learn about it, see the whole animal, they can point to the piece that they found.*
- *Teachers can see their fossil being cataloged – connection between visual and tactile… how it is obtained -> where it is going. Teachers know they are part of real science. We actually need your help. It's process + storyline. It's authentic and seeing the entire process – how we go from A to B to C. It gives them a better idea of how science is done.*
- *They get be a part of the scientific discussion. It's not a bad thing. It's just how you advance science. I saw that when I was an undergrad and I was shocked.*
- *GABI – really good – so many scientists working on so many pieces. Epitome of interdisciplinary. It appealed to a lot of groups. You have the field site, the wrap up meetings, 5 years later we are still following up. That their work at that time was relevant. 90% was a cool experience - that's a hook – it stays cool because they are invested. We still the teachers that started 5 years ago. Seem to be interested and engaged. They seem to want to come back. They continue to reach out to us with valid questions, want to see what else they can do. Have built a sense of community –so it has organically branching off, so people are creating lessons.*
- *I did a lesson with Megan on Planetary that we put on the GABI.*
- *We're expanding their network to other teachers and us, and other people they have met and communicated about this project. They find that SO many people are interested in the work.*
- *One of the teachers is on the advisory board at our non-profit*
- *In Panama – there were a lot of new sites. The rate of new occurrence is lower. Maybe do reconnaissance, and starting at the beginning is exciting. Starting at the earliest stage is a bonus… typically where there is water, so we explored lakes in Panama. Look for sites that have potential for finding completely new things – life changing experience. But we had a lot of failures in Panama (Lago Aguilayla – not many fossils). But every day we found a new taxa (that's exciting for teachers),*
- *Lago Byana – going to an island where no one had walked –teachers said that was very exciting. Tough to pull that off in North America. It was a bigger challenge to do the work in Panama, even year-to-year.*
- *I'm not convinced how much it affects the teachers- them having the experience. If it's an old site, you can tell them the history. New sites we don't have the background – they are learning in parallel. Even if we don't find anything, they experience the process of science. It addresses the fallacy that science is clean. We document a lot more here.*

The teachers feel they are an email away from a scientist, and what that affords then. How do you sustain this? What is Phase 2? What is the bridge?

- *The teachers I have worked the most with – I see them more – go out looking for fossils in the river. I have a stronger relationship with them.*

- *Being Facebook friends, I know what is going on with them. Katy asked me to be a skype in scientist and it was easy – no need to craft an email.*
- *It would be nice to be on a listserv so you knew what was going on. We have a special group for teachers. Any time we do a project, we encourage them to set up a group.*
- *A lot of the teachers have gone above and beyond to present the work – they put the scientist name on it, but don't tell them. No way for me to vet it.*
- *We need to educate them on the etiquette of publishing. How to build a talk or poster and how participation affects us – we are still creating lessons. The intent was them to design lesson, presenting exceeds the expectations (unexpected outcome).*

How to prepare teachers for the field experience

- *76% has some experience, but some were overwhelmed*
- *We did an orientation - last one, Victor gave talk on sharks – went to Santa Cruz to give the talk and did a field trip.*
- *What do you hope to get out of this? (listing on board)*
- *You can't go out into field without knowing something – here's where we are going, here's why it's important, here's what the rocks look like, here's what animals we expect to find.*
- *For international, entering a new culture, and that was hard.*
- *Some people got seasick – should explain rigors (on a boat, hacking with a machete). Show them video footage or pictures of what people were doing. Here are the conditions! Other teachers narrating.*
- *We had teacher mentors on each new trip – so they can fill in the gaps that we don't think about.*
- *Need to know what to wear each day. Field mentor should explain things. Would be good to have more teacher mentors, we had 2/session.*
- *Used MyFossil website to connect – message board*
- *Yeah but people ask for that but then they don't use it.*
- *People upload video profile ahead of time.*
- *One of the groups didn't click – was not good for the mentors and leaders either.*
- *Changes from cohort 4 to 5, forced people to change groups all the time. Made sure people were mixing it up. Sit in different spaces at poolside chat. (Jeanette – it didn't feel heavy handed). Ian – we tried to be subtle about it. All of us student mentors – it was our first time – it was new to us.*
- *In the California project, we had a school and county divide - it's good for people to come with colleagues, but there are some outsiders.*
- *In Cohort 4, had 4-5 people drop out.*
- *Diversity helped – different regions, more interest between people, opens up discussion.*
- *In 2013, had two teaches from NM – Kytana, Navajo – had different experiences – small group Had them go with different scientists to mix it up… did a different thing – could choose what they were interested in – we need 8 volunteers – who wants to do what – in the name manner we did the hikes this morning.*
- *2014 group – teachers invited us to dinner and poolside chats – go to hand out a lot Hani. Didn't see the connections among teachers. 2015, to know the teachers, stayed with them.*

- *2015 group – we were cataloging at night, and going off to other sites without the teachers*
- *Changes from 4 - went to canal sites, the student mentors only did one week, not the full two weeks*

Tuesday

Tuesday Mentor

Value of classroom visits, role visits, PD model

- *Changes the perception of what a scientist is – becomes broader – may not be the one type in your mind.*
- *You can pick a major and a career that's fun. I like to hike and be outdoors, look I found a career that lets me do those things. Find something you love and find someone who will pay you to do it.*
- *My favorite hobby is my job.*
- *Got started in the GABI stuff – got started with y2 in Aptos HS, another had resources, freedom, helped to develop curriculum. Students asked me to take his class when he was moving on. This one girl was not interested, but then at the end of the year asked me how she could become a geologist. She had no idea it existed. Another student said he wasn't interested in paleo, but loved the 3D.*
- *I followed up in some classes that another had visited and they still talked about him and they fell like they can still contact him.*
- *Even if they don't send the email, it's empowering that they think they can. Can you name a scientist? Most people can't name a scientist*
- *The most obvious thing that hasn't been said is we provide content that the teacher can't provide. When you are presenting, the teacher can catch things they need for their classroom. Pretty useful to have us go first, work out the bugs, let the teacher see those bugs, as we get better, then let the teacher do it themselves.*
- *One of us would do the first couple classes, then I would do the later classes.*
- *Classroom management is our biggest challenge…*
- *Different skill levels with teachers too - you can see the class.*
- *I am there for content and to refine the lesson.*
- *Different tiers of the content – talk through people about a series of ideas of lesson*
- *One of the things about GABI is that teachers get credibility from pictures of them being the field; then the scientist shows up and is their friends – gives the teacher more credibility. Students knowing they are part of real science, and their teacher is part of real science I meaningful.*
- *Maggie said that she tells stories and the kids think they are getting her off topic.*

Appendix D: Mentor Survey

PCPPireTeach and GABI RET Mentor Survey

This survey seeks to help us better understand your role and experiences with teachers while you participated in the Panama Research for Teachers project. Five cohorts were included in this program from 2012 to 2016 with cohorts 1 to 2 participating in PCPPireTeach and cohorts 3 to 5 were participating in GABI RET. Please consider your experiences when you were in Panama *with the teachers, as well as other activities that may have occurred. We use the terms "mentor" and "mentoring" below to indicate the work that you did, your collaborations with the teachers during this Panama experience, and any phases of professional development. Please complete all items as thoroughly as possible.*

1. During which cohort(s) did you participate?
   - 2012 (Cohort 1)
   - 2013 (Cohort 2)
   - 2014 (Cohort 3)
   - 2015 (Cohort 4)
   - 2016 (Cohort 5)

2. Did your understanding of teaching and learning change as a result of working with your teacher partners? If so, how?

3. If you had an opportunity to visit a classroom, how did your visit impact you? If you visited more than once, how did your visits change over time?

4. Explain how working with teachers on the Panama project influenced your implementation of the scientific process in your own work.

5. What did you learn about mentoring from working with the teachers during this experience? What surprised you most about these interactions?

6. Please rate the following on your level of agreement BEFORE and AFTER your Panama experience.
Please use the following scale:
   - 5 = Strongly Agree
   - 4 = Agree
   - 3 = Neither Agree nor Disagree
   - 2 = Disagree
   - 1 = Strongly Disagree

	Rating BEFORE	Rating AFTER
Working with and mentoring teachers benefits scientists as science professionals (in terms of career and identity as a professional scientist).		
Working with and mentoring teachers benefits scientists as educators (in terms of attitudes toward teaching and learning as educators).		
Working with and mentoring teachers benefits scientists as individuals (in terms of fulfillment and giving back to the community).		
It is a benefit to teachers to have a scientist as a mentor.		
I am able to communicate science concepts simply and effectively (in layman's terms).		

7. Please indicate the number of each type of continued collaboration you have had with any of the teachers.

	Number
Developed lesson plans	
Classroom visits	
Conference presentations (papers and/or posters)	
Co-authored a research paper	
Virtual lecture	
Offered field experiences	
Other, please describe.	

8. To what extent do you agree with each of the following statements about your experience as a mentor?
Please use the following scale:
5 = Strongly Agree
4 = Agree
3 = Neither Agree nor Disagree
2 = Disagree
1 = Strongly Disagree

	Rating
Working with and mentoring teachers as part of this research experience enabled me to see how they benefited from our interactions.	
I benefited from working with and mentoring teachers as part of this research experience.	
My experiences in working with and mentoring teachers as part of the Panama project were positive and I would participate again in the future.	
Working with and mentoring teachers changed my views about the demands and needs of K-12 teachers.	
I have better understanding of working in the classroom with K-12 students.	
As a result of my participation, I have a greater interest in teaching in K-12 settings.	
I would like to work with and mentor (a) K-12 teacher(s) in the future.	
As a result of mentoring teachers, I gained a better understanding of how to work with students.	
As a result of mentoring teachers, I gained better communication skills.	
I feel it is important for teaches to have field-experiences as part of their educational training.	
I feel it is important for students to have inquiry-based learning opportunities.	

9. Has working with teachers as a mentor made you a better scientist? If so, in what ways?

10. What changes, if any, have you made in your work as a scientist as a result of mentoring teaches as part of the Panama experience?

11. Do you have any additional comments to add?

Appendix E: Teacher Practice and Effects Survey
Dear GABI RET Educators,
We are so grateful for your effort and willingness to learn and grow. As we near the end of this project, we are beginning a summative evaluation in hopes of capturing the impact the experience has had on you, your teaching, and the scientists you worked with. As part of our efforts, we are asking you to complete the following survey. The survey should take you between 15 and 30 minutes to complete. Your responses are completely anonymous and we ask you give your name only so that our evaluator can track completions and follow-up only with those that we have not yet heard from.

Please complete all of the items as completely as possible. If you have any questions or issues, please contact our evaluator Bradford Davey at brad@techforlearning.org.

Thank you,
The GABI RET Team

Teacher Practice and Effects Survey

Educator Demographics
Please tell us about yourself:
Your name (for tracking completions only – your responses are completely confidential)

Gender

Male	
Female	

Please select the racial category or categories with which you most closely identify by checking the appropriate box.

American Indian or Alaskan Native	
Asian	
Black or African American	
Native Hawaiian or Pacific Islander	
White	
Some other race	
Do not wish to provide this information	

How many years have you been an educator?

<1	
1-2	
3-4	

5-6	
7-8	
9-10	
11-15	
16-20	
21-25	
26-30	
>30	

What other field experiences have you had in addition to your GABI RET experience?
<open response>

What age group do you teach? (check all that apply)

K-4
5-8
9-12

What subject(s) do you currently teach (check all that apply)

Biology
Chemistry
Earth science
Engineering
General science
Geology
Mathematics
Physics
Other (Please describe)

Educator Field Experience

Indicate the importance of each of the following learning outcomes from your field experience:
(1=not at all important, 10=highest importance)

___ Enhanced critical thinking and problem-solving skills
___ Development of social and professional relationships with peers and scientists
___ Increased confidence in working with “real” data and problems
___ Integrated knowledge from a range of sources
___ Developed paleontology expertise
___ Developed proficiency in field skills
___ Developing scientific behaviors such as researching, asking questions, using data, communicating results, etc.
___ Learned how paleontologists think and reason
___ Developed ways to translate field experience into classroom activities
___ Utilized field experiences to develop lessons and lesson plans

STEM Careers

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

"I know …" (SD=Strongly Disagree, D=Disagree, N=Neither Agree or Disagree, A=Agree, SA=Strongly Agree) (Friday Institute)

___ About current STEM careers
___ Where to go to learn more about STEM careers
___ Where to find resources for teaching students about STEM careers
___ Where to direct students or parents to find information about STEM careers

Educator Practice

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement. (SA – Strongly Agree, A – Agree, UN – Uncertain, D – Disagree, SD – Strongly Disagree)

___ When a student does better than usual in science, it is often because the teacher exerted a little extra effort.
___ I am continually finding better ways to teach science.
___ Even when I try very hard, I don't teach science as well as I do most subjects.
__ When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.
___ I know the steps necessary to teach science concepts effectively.
___ I am not very effective in monitoring science experiments.
___ If students are underachieving in science, it is most likely due to ineffective science teaching.
___ I generally teach science ineffectively.
___ The inadequacy of a student's science background can be overcome by good teaching.
___ The low science achievement of some students cannot generally be blamed on their teachers.
__ When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.
___ I understand science concepts well enough to be effective in teaching elementary science.
__ Increased effort in science teaching produces little change in some students' science achievement.
___ The teacher is generally responsible for the achievement of students in science.
__ If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.
___ I find it difficult to explain to students why science experiments work.
___ I am typically able to answer students' science questions.
___ I wonder if I have the necessary skills to teach science.
__ Effectiveness in science teaching has little influence on the achievement of students with low motivation.
___ Given a choice, I would not invite the principal to evaluate my science teaching.
__ When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.
___ When teaching science, I usually welcome student questions.
___ I don't know what to do to turn students on to science.
___ Even teachers with good science teaching abilities cannot help some kids learn science.

During science instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.) how often do your students. (N=Never, O=Occasionally, A=About half the time, U=Usually, E=Every time, NA=Not Applicable)

___ Develop problem-solving skills through investigation (e.g. scientific, design or theoretical investigations)
___ Work in small groups
___ Make careful observations or measurements
___ Use tools to gather data (e.g. calculators, computers, computer programs, scales, rulers, compasses, etc.)
___ Recognize patterns in data
___ Create reasonable explanations of results of an experiment or investigation
___ Choose the most appropriate methods to express results (e.g. drawings, models, charts, graphs, technical language, etc.)
___ Complete activities with a real-world contact
___ Engage in content-driven dialogue
___ Reason abstractly
___ Reason quantitatively
___ Critique the reasoning of others
___ Learn about careers related to the instructional content

“I think it is important that students have learning opportunities to…” (SD=Strongly Disagree, D=Disagree, N=Neither Agree or Disagree, A=Agree, SA=Strongly Agree)

___ Lead others to accomplish a goal
___ Encourage others to do their best
___ Produce high quality work
___ Respect the differences of their peers
___ Help their peers
___ Include others’ perspectives when making decisions
___ Make changes when things do not go as planned
___ Set their own learning goals
___ Manage their time wisely when working on their own
___ Choose which assignment out of many needs to be done first
___ Work well with students from different backgrounds

Appendix F: Teacher Content and Experience Questionnaire
GABI RET 2017
Content and Experience Questionnaire

Dear GABI RET Educators,
We are so grateful for your effort and willingness to learn and grow. As we near the end of this project, we are beginning a summative evaluation in hopes of capturing the impact the experience has had on you, your teaching, and the scientists you worked with. As part of our efforts, we are asking you to complete the following questionnaire about concepts key ideas associated with the GABI. We area also asking you to answer a few questions about your

immersive field experience and what you have done with what you gained. The survey should take you between 15 and 30 minutes to complete. Your responses are completely unanimous and we ask you give your name only so that our evaluator can track completions and follow-up only with those that we have not yet heard from.

Please complete all of the items as completely as possible. If you have any questions or issues, please contact our evaluator Bradford Davey at brad@techforlearning.org.

Thank you,
The GABI RET Team

Content Questions

Your name (for tracking completions only – your responses are completely confidential)

1. When did the Isthmus of Panama close completely?

2. What is the geological epoch name for the age of the Gatun fossil localities?

3. How were fossil marine faunas affected by the final closure of the Isthmus?

4. Give three examples of animals that lived in Panama in the past, but are extinct there now.

5. How can land mammals and marine animals be found in the same fossil locality?

6. Which of the following animals migrated from North to South America during the Great American Biotic Interchange? (circle all the correct responses)
   a. horses
   b. sloths
   c. monkeys
   d. armadillos
   e. rhinoceroses
   f. camels

7. Why do paleontologists wash sediments through screens?

8. Briefly describe how the Biomuseo interprets science content that pertains to paleontology.

Immersion Experience

1. How has immersion in practice (from stating questions/hypothesis, designing a research plan – data collection and data interpretation-, and presentation of results) through participation in GABRI RET evolved your classroom teaching practice?

2. How are you implementing the scientific process in your lesson planning and teaching?

3. How many lesson plans have you developed/implemented resulting from this experience?

4. How has implementing the scientific process in your classroom affected your students interest in STEM and STEM careers?

5. How many lesson plans have you developed and/or implemented or How many specifically related to you as a member of the GABI project. <number> <content focus or each?|>

6. Have you presented at a professional meeting (teacher focused or STEM focused) that describes your experience resulting from this project. <Yes, No> <Which conferences?>

7. Have you continued to collaborate with any of the STEM scientists you have meet as a result of this project.
<Yes, No, if so who are they and how?>

Appendix G: Teacher Responses to the question, "*How are you implementing the scientific process in your lesson planning and teaching?*"

- *Gave me real world examples that I did to lead students through.*
- *Because I have been in the field with scientists and have worked with them to interpret peer-reviewed articles, I feel more comfortable asking questions from the perspective of a scientist and critically analyzing data.*
- *I believe that hands on field type experiences are very valuable to the students. I take every class I teach into the field to participate in experiences that mirror those I had in Panama.*
- *Students love to hear personal scientific stories: my teaching has another layer now, I have field experience working alongside scientists that I never had before. I am a more confident teacher in some regard too. I can now involve students in the scientific process in a more meaningful way.*
- *I am not a classroom teacher but for me the scientific community at STRI, where scientists from multiple disciplines engage with one another, was a strong model for K-12.*
- *We have a creek near our school and my field experience in Panama has greatly changed how I visit the creek with my students. We find shark teeth all the time but now we use those shark teeth and other found fossils to collect data, ask questions, draw conclusions, sketch ecosystems, etc.*
- *This firsthand experience I had the privilege of taking part in with GABI RET gave me the opportunity to live my dream of discovering and working with fossils. As a natural historian, I used these experiences to recreate digs for my students. The understanding of the process, the tools used, the excitement and interpretation- my students get this same opportunity and this hopefully inspires their future learning.*
- *I was very weak in the area of science when I started this project. I felt unsure of myself and shy. This experience has given me confidence. I try to recreate experiences like I had*

for my students. They CAN examine fossils and make discoveries. They can use measurement and data tables to have focused academic conversations.

- *I like that I can share a real-world scientific debate and data collection with the classroom.*
- *I feel that my experiences conducing field work in Panama have allowed be to give my students a more realistic view of the nature of science. I can now talk about scientific research that I have participated in and tell the stories of the grad students and scientists that I worked with in Panama. I also now have the ability to ask the scientists if a student has a question that I don't know the answer.*
- *It has provided me with a real world/authentic model of paleontological, scientific, and engineering practice that I can share with teachers in my local area and students that exhibit their research at our annual County Science & Engineering Fair.*
- *My students love hearing about the real-world side of paleontology and the links to what we are discussing in class. I already did a lot of inquiry based science, but I am now attempting to incorporate project based learning as well.*
- *The GABI-RET process has given a lot of confidence in class to create real world-based lessons that give students exposure to STEM careers as they learn the science concepts.*
- *I start every day of class with driving and focus questions, frequently make connections to human curiosity about the world, and always give those as the reasons for learning the skills for scientific investigation.*
- *I use the PIRE and GABI experience multiple times throughout the year to help 8th grade science students understand, appreciate, and become excited by real scientists and how they work, as well as real discoveries. I show photos and bring in fossils to pass around to keep their attention. Questions arise naturally and interest grows quickly.*
- *GABI RET strengthened these practices. Students are now engaged in more activities that support developing scientific argumentation as another practice.*
- *Since I returned from Panama, I have included more inquiry based activities in my lesson planning.*
- *It validated how I worked with my students both for them and for myself. What was also powerful was having GABI RET scientists visit my classrooms to work with my students through this scientific process.*
- *Through this practice, I was reminded about the DOING of science; something that many science educators have not had the opportunity to do. This has encouraged me to engage students in our district mainly in the practices of science.*
- *The GABI RET experience really helped me hone in on practices to encourage students' using evidence to justify their response to a 'phenomenon'. My students are learning during a time in which science education encourages respectful discourse regarding different answers to the same question. My experience in GABI RET offered the remarkable experience of presenting me with a question, providing me evidence, and encouraging me to justify my position.*
- *It has changed the way I talk about the process of doing science. I try, more frequently, to bring in big questions that don't have an easy answer, and I try to highlight where there are controversies, why there are controversies, and how scientists can address the controversies.*
- *My experience with GABI RET was exactly in line with how I engage students in my classroom in the scientific process. Now I have a greater focus on fossils.*

- *Participation in GABRI RET has supported me in assuring that every activity I do with elementary students, whether in the science realm or not, involved the development of student questions based on shared experience of the world outside the classroom. That shared experience leads to the gathering of information from a variety of sources, integrating and interpreting that information, and presenting results to an audience.*
- *The experience of GABI RET offered an opportunity to re-engage in the practice of science. This translated into more authentic experiences for my students in the scientific process.*
- *I was already teaching science like that. The experience just reinforced what is done in the field and gave me a reference point to discuss with my students as to how science is implemented in the field.*
- *For me personally, this did not change much as it was a practice I was already using. What did change was my comfort level with fossil content.*
- *I have a greater understanding the process scientists use during research. I have always been able to teach the scientific method, but experiencing science in action and implementing the scientific method during research gave me a powerful level of understanding and experience to bring to my students.*
- *By actually participating in field work and having hands on opportunities the scientific process was learned much better through practice.*
- *I have created and implemented a unit on fossils. Students collect, wash, question and hypothesize while putting pieces together.*
- *It has strengthened my classroom practice in that I was able to experience these practices for myself and can transfer that experience to my students.*
- *I have added the horse tooth evolution inquiry lab.*
- *By allowing students to recognize that they are immersed in the practice of the scientific process all the time, they just haven't defined it as such.*
- *I feel better able to probe students for understanding. The experience helped me learn to develop appropriate questions to lead students to the answers they're looking for.*
- *This experience has pushed me to think more about engaging phenomena as an engaging introduction to scientific discovery. It has also led me to focus on questions and science practices.*
- *The immersion opportunity was unique and allowed me to get a peek instead the scientific world. Prior to the experience, I didn't know how scientists engaged in research and it was much more fluid than I had imagined. This has evolved in my math classroom through the importance of asking questions, attending to precision, and justification for ideas and procedures.*

Appendix H: Detailed Teacher Comments about Future Experiences

Group 1

- *Maintaining support for teachers*
- *Scaffolding for different subjects*
- *Keeping enthusiasm in Prof Dev Community*
- *Fresh blood*

- *Expanding enrollment*
- *More field work in unique places*
- *One day options to teachers in new regions – local outreaches, that they could relate to their classes*
- *Preventing people from developing similar things, a lot of overlap, wish I had worked with them*
- *Creating a diversity of artifacts (infographics, blogs, informative videos) in addition to lesson plans (which are often longer) – for broader impact have some smaller scale things.*
- *Having spread out time to do lesson planning – 90 minutes every 3 or 4 days.*

Group 2

- *Needs – engage in authentic science through field experience, include cultural experiences*
- *Design – how to I take this to students? More attention to pre-institute (how-tos, background info)*
- *Implementation – build in down time and breaks, post program experiences for colleagues, invite teachers to observe – they need a hook – could be local*
- *Outcomes – fewer lessons that are higher quality (need time, collaboration, vetting, piloting)*

Group 3

- *Design – quarter of people on new venture would be old GABI people, lower teacher mentor/group ratio, field experience, cultural part – museum visits, lectures*
- *Implementation – collecting and keeping, important to students, lab visits, regular contact with scientists – keep regular contact with participants, down time. Rather than 20 scientific articles, replace some of that stuff with videos and simpler stuff (like about geology)*
- *Time for reflecting*

Group 4

- *Design – having GABI RET leaders communicate with our site administrators about what we are participating in*
- *Teacher collaboration – quarterly check in on web*
- *Field work in summer – 7-10 days, varied localities*
- *Embed time within the face-to-face to collaborate with each other and the science mentors*
- *Implementation – funding for resources, 1-2 lessons per year, google classroom to share*
- *Outcomes – lessons to share within the national community, sharing our lessons at our site, standard teacher and student surveys – simple, pre/post. Need to collect evidence on student impact.*
- *Tell people in advance who they are going to meet – the scientists, bring resources so ready to plan, peer review*

Group 5

- *Choosing people who can work together – more than one elementary teacher*
- *GABI could partner with other programs – on oceans…*
- *Physical accessibility – having choices, better housing, like in Panama (boat or screen washing)*
- *Go to obscure localities and presenting to kids*
- *More time after to plan with your peers, and throughout the year*
- *Admin contact from Bruce – there is release time in the PD schedule to extend the work since it is enhancing the science curriculum*

Detailed Mentor Responses

Group 1

- *Audience – expanding, more diversity geographically, get teachers from the state where we are going, invite some students, contiguous states (FL and GA with theme) What's the same? What's different? Teach that in the setting. Have more cohesive story. Push teachers to talk more about the science. More context and specificity. Teachers learn more, deeper. Questions students have in the field could drive lesson development.*

Group 2

- *Getting to part of the actual discussion with scientists (Tupper talks, Bambi). UFL – Friday afternoon talks. During the intro, we do science presentations. Have returning teachers talk about how they used (as part of intro). Have larger percentage of teachers be leaders (30%). Helping with tips. Teachers showed a lot of fossils they got to take back. Find a way to allow the teachers to take something back. In NM, more geology. Involve Scott (local tour).*

Group 3

- *25% past participants. Have pairs come from a school (2 to a school). Logistics – Can we do it another time of year? Do we need the full two weeks? Webinars prior to face-to-face, content seminars, get to know each other, background. More time in the field when they are together.*

Additional Responses

- *Teachers teaching diverse subjects*
- *Teachers found GABI fossils – we don't know what they found. Give them pictures for "could be found" Then put on website with what the teachers found.*
- *Pre-survey at beginning to see what they know, before they come.*
- *Keep track of collaborators – give mentors a list of what they are keeping track of…*
- *Teach the teachers how to do a poster, and research etiquette*

All-Group Follow-up suggestions

- *Reached out to schools and students in an area so they can work together and build in diversity, let students share their findings.*
- *Have a chance to bring at least one student on the field experience to inspire other students.*

- *How do you keep people accountable after the experience? Some cohorts were better. Some people went to Panama and then disappeared. Intentional design could help. Like iDig, 3 years, one lesson/semester and bring it back.*
- *We could help and clean those fossils, catalog*
- *Like the horse bone I found this year – I would make that my focus this year, but I don't have it and it could just go sit in a drawer – maybe a loan, or picking over spoil piles. 3D model is different – It's a model – way more excited about the real fossil.*
- *There is a positive thing that having a group in CA and in FL so there are local field trips, local knowledge. Use that to grow. Who do I talk to in CA? (a Paleo person). Local connection is very important.*
- *Classroom visits by scientists is great – we went to Yutana's classroom and Gary's museum. We toured a HS in Panama. Let's try to visit classrooms. So, virtual connections between your classes – students do skype with each other*
- *Need a place to share resources, people, lessons, ideas. Systems where we spend less time searching for things.*