Collaborative Research: Geodesy curriculum for the 21st century--Innovative science for addressing societally critical issues

**Project Period:** 07/01/2013-06/30/2018 (original end date 6/30/16 extended to 2018)

**Reporting Period:** 07/01/2016-06/30/2017

**Principal Investigators:** Meghan Miller (PI), Donna Charlevoix (Co-PI), Beth Pratt-Sitaula (CoPI)

**Sponsor:** NSF DUE-TUES

**Award ID:** 1245025

**Collaborators:** Bruce Douglas (Indiana University), Rebecca Walker (Mt San Antonio College)

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*Screen shot of recently published GETSI module called “GPS, Strain, and Earthquakes”. Students access and analyze Plate Boundary Observatory GPS data.*
Accomplishments

What are the major goals of the project?

Recent technological innovations in geodesy (the measurement of the size, shape, and mass distribution on Earth and changes over time) have allowed a wide range of advances in our understanding of Earth processes on topics critical to society such as natural hazard mitigation, climate change, and water resource management. Undergraduate teaching resources have not kept pace. GETSI (GEodetic Tools for Societal Issues) is a curriculum development and dissemination project to increase the representation of geodetic data use by both introductory and majors-level undergraduate students. GETSI is partnered with the SERC (Science Education Resources Center) InTeGrate project (Interdisciplinary Teaching about Earth for a Sustainable Future) for curriculum design, assessment, and evaluation. The project will produce four modules that encompass about two weeks of class time each – two at the introductory level and two at the majors’ level.

Overarching Objectives

1. Improve geoscience (particularly geodetic) knowledge base of undergraduate students both for general science literacy (introductory) and future science workforce (majors-level).
2. Improve effectiveness of teaching resources and pedagogy employed by faculty members teaching geodesy, geoscience, and allied sciences.

TUES Type 1 Outputs

1. Development, testing, revision, and dissemination of five curricular modules featuring geodesy data investigations on societally important topics which support Earth science and quantitative literacy at both introductory and majors’ levels in diverse academic settings.
2. Developers’ manual to facilitate future integration of geodesy and other data into teaching materials.
3. Support for faculty in integrating curriculum into courses

TUES Type 1 Outcomes

1. Students:
   a. Are able to apply authentic geodetic data and quantitative reasoning to addressing critical societal issues
   b. Have improved understanding of nature and methods of science
   c. Gain better understanding of relevant geoscience and climate literacies and the ability to apply them to critical resource, hazard, and environmental issues
2. Faculty
   a. Adopt developed geodesy curriculum modules
   b. Include more connections between authentic data and addressing of critical societal issues
   c. Increase use of promising pedagogical practices in STEM education
   d. Use systematic assessment of student learning
What was accomplished under these goals?

Major Activities

- Output #1 will be accomplished by the end of this reporting period.
- (Output #2 was accomplished in the last reporting period)
- Output #3 is nearly accomplished but a small amount of remaining work will be done in the last year.

The Report from the External Evaluator states “the project met or exceeded its goals in outputs, outcomes, and long term outputs through ongoing community engagement.” More details, including website use so far, are included in the Appendix: “Final Evaluation Report” by the Science Education Resource Center (SERC).

Output #1: The three remaining modules were published during the reporting period. GPS, Strain and Earthquakes [majors], Measuring Water Resources with GPS, Gravity, and Traditional Methods [majors], and Surface Process Hazards [intro]. (Publication date for the final module Surface Process Hazards is June 28, 2017.)

Output #3

- GETSI held a highly successful short course in collaboration with University of Houston NSF TUES project (Integrating GPS and LIDAR Into Geoscience Education) and American Geophysical Union (AGU). December 11, 2016. Hooking undergraduates into geophysics data and methods (GPS, Lidar, InSAR, SFM photogrammetry) through societally important issues. Twenty-six university faculty members were introduced to two of the GETSI modules (GPS, Stain, and Earthquakes and Imaging Active Tectonics) and one GETSI Field module. They were given an overview of the science content, had time to practice using elements of the module as students would, and then did implementation planning for their own courses. Survey results were highly positive with an average rating of 9 out of 10 (10 being “very satisfied”). All participants indicated plans to use elements of at least two modules and 85% stating intention to use elements of all three.
- GETSI also collaborated on two webinars with the NSF STEP Center InTeGrate Project, feature a total of three GETSI modules.
  - Addressing Earthquake Hazards with LiDAR, GPS, and InSAR in Upper-level Undergraduate Courses – April 13, 2017. Featured GPS, Strain, and Earthquakes and Imaging Active Tectonics. Forty-eight participants.
- Dissemination of GETSI collection in posters and presentations at Earth Educators Rendezvous, Geological Society of America (GSA), and AGU as well as through UNAVCO and partner listservs.
- Engaged in outreach from the UNAVCO and National Association of Geoscience Teachers (NAGT) booths at both GSA and AGU.
Initiated the feedback surveys for collecting information on how instructor users of GETSI teaching materials actually implement them in their courses.

**Opportunities for training and professional development?**

GETSI materials authors receive professional development related to pedagogical best practices for geoscience teaching. Participants in webinars and short courses receive professional development related to both pedagogy and geodesy content.

**How have results been disseminated to communities of interest?**

As described above in Major Activities Output #3, modules have been disseminated via a short course, webinar, conference booths, conference presentations, listservs, and websites. GETSI is also featured on the UNAVCO website as a major project (http://www.unavco.org/projects/projects.html#Major) giving it prominence beyond just the Educational section, which tends to be limited to a smaller subset of the UNAVCO community.

**Plan for next reporting period?**

In the small amount of remaining effort for the grant, we will continue to solicit feedback surveys from faculty users of the curricular materials developed during the grant and for dissemination activities.

**Products**

**Conference Papers and Presentations**

Title: Data-rich societally-relevant undergraduate teaching resources for geoscience classrooms and field courses  
Conference: Earth Educators Rendezvous 2016  
Authors: Donna Charlevoix, Beth Pratt-Sitaula, Bruce Douglas, Becca Walker, Chris Crosby, Katherine Shervais

Title: Data-rich societally-relevant undergraduate teaching resources for geoscience classrooms and field courses  
Conference: Geological Society of America 2016  
Authors: Beth Pratt-Sitaula, Bruce Douglas, Becca Walker, Benjamin Crosby, Donna Charlevoix, Chris Crosby, Katherine Shervais

Title: Societal challenges-oriented data-rich undergraduate teaching resources for geoscience classrooms and field courses  
Conference: American Geophysical Union Meeting 2016  
Authors: Beth Pratt-Sitaula, Becca Walker, Bruce Douglas, Benjamin Crosby, Donna Charlevoix, Chris Crosby, Katherine Shervais

**Websites**

GETSI Project Site: http://serc.carleton.edu/getsi/index.html
Participants

Individuals

Meghan Miller UNAVCO PI 0 Months
As the UNAVCO President Miller is responsible for coordination with the science community and the successful accomplishment of the work. She is paid entirely out of indirect as her work is for the proportional benefit of all awards; thus she does not draw salary on this grant.

Donna Charlevoix UNAVCO Co-PI 0 Months
As the Director of UNAVCO's Education and Community Engagement, Charlevoix is also responsible for coordination with the science community and the successful accomplishment of the work. Her salary is covered through the NSF GAGE Facility Cooperative Agreement.

Beth Pratt-Sitaula UNAVCO Co-PI 1 Months
A UNAVCO Educational Specialist, Pratt-Sitaula serves as the GETSI facilitator in charge of project logistics and communication. She coordinates between UNAVCO, the authors, technical experts, beta-testers, SERC, NAGT, and related organizations. She leads dissemination (meeting presentations, journal papers, articles, website content, webinars). Pratt-Sitaula's funding to work on GETSI is from this NSF TUES grant.

Gareth Funning UC Riverside Faculty 0 Month
Funning served as module co-author with collaborator Bruce Douglas (Indiana University) on the majors-level module "Imaging Active Tectonics" in previous award years. This year he was involved in dissemination for work on the AGU short course and a webinar. His full time job is as a faculty member at UC Riverside. He received $600 stipend in this project year for dissemination work.

Phil Resor Wesleyan Univ Faculty 0 Month
Resor served as module co-author on the majors-level module "GPS, Strain and Earthquakes". This year he was involved in module revision and a webinar. His full time job is as a faculty member at University of Kansas. GETSI paid him a total of $1500 stipend for this project year.

Vince Cronin Baylor Univ Faculty 0 Month
Cronin served as module co-author on the majors-level module "GPS, Strain and Earthquakes". This year he was involved in module revision and the AGU short course. His full time job is as a faculty member at Baylor University. GETSI paid him a total of $2100 stipend for this project year.

Eric Small Univ. of Colorado Faculty 0 Month
Small is serving as module co-author with collaborator Bruce Douglas (Indiana University) on the majors-level module *Water Resource Geodesy*. His full time job is as a faculty member at University of Colorado. GETSI paid him a total of $7500 stipend over the period of work on module development and revision.

Sarah Hall Coll. of the Atlantic Faculty 0 Month
Hall is serving as module co-author with collaborator Becca Walker (Mt San Antonio College) on the introductory level module *Surface Process Hazards*. Her full time job is as a faculty member at College of the Atlantic. GETSI paid her a total of $7500 stipend over the period of work on module development and revision.

Ellen Iverson SERC 0 month
Iverson is the lead assessment consultant and external evaluator for the GETSI project. She is paid by SERC (Science Education Resources Center) via an subaward from this NSF TUES project.

Stuart Birnbaum SERC 0 month
Birnbaum is the assessment consultant for the majors-level modules. He is paid by SERC (Science Education Resources Center) via a subaward from this NSF TUES project.

Monica Bruckner SERC 0 month
O’Connell is the webmaster for the GETSI project. She supports any team needs related to the SERC-hosted GETSI website and all issues related to submission of student data for assessment review. She is paid by SERC (Science Education Resources Center) via a subaward from this NSF TUES project.

**Organizations**

**Type: Academic Institution**
**Name:** SERC (Science Education Resource Center)
**Location:** Northfield, MN
**Contribution:** Assessment and evaluation; dissemination
**Details:** SERC is providing assessment design, external evaluation, and project dissemination through a designated subaward. GETSI module design and assessment are following the model of SERC’s InTeGrate project. Modules are being reviewed by expert assessment consultants and student data will be collected using the InTeGrate collection system. SERC is also hosting the GETSI website and providing content management assistance for the site and webinars. As needed, GETSI announcements go out through SERC channels to the wider geoscience community. Ellen Iverson, a SERC assessment specialist, is providing external evaluation of the GETSI project (see report in Significant Results section).

**Type: Other Nonprofits**
**Name:** National Association of Geoscience Teachers (NAGT)
**Location:** Northfield, MN
**Contribution:** Collaborative Research
**Details:** NAGT is collaborating with GETSI on dissemination. For example, as part of publicizing GETSI webinars, announcements went out on NAGT listservs.

**Type: Other Nonprofit**
Name: American Geophysical Union
Contribution: Collaborative Research
Details: AGU collaborated on the hosting and recruiting for the short course held immediately before AGU annual meeting 2016.

Type: Academic Institution
Name: University of Houston
Contribution: Collaborative Research, Financial Support
Details: The UH project “Integrating GPS and LIDAR Into Geoscience Education” co-sponsored with GETSI, the short course immediately before AGU annual meeting 2016

**Impacts**

**What is the impact on the principle discipline?**

Geodesy encompasses an increasingly important set of geoscience methods for better understanding earth processes. Its scope has greatly increased from early applications of surveying and tectonic plate motions to include critical insights into natural hazards (ex. earthquake, volcanoes, landslides), climate change (ex. ice mass and sea level change), and water resources (ex. groundwater storage and change). However, the field remains fairly technical and access to some data sets is limited. Therefore undergraduate students are seldom given the chance to analyze geodesy data. This is a critical omission for a toolbox of techniques needed for the next generation of science literate citizens and geoscience workforce members. GETSI is working to address part of this gap through the development and dissemination of high quality teaching modules for both introductory and majors-level courses that feature geodesy data analysis.

**What is the impact on society beyond science and technology?**

As our global population continues to increase, living in ever more marginal lands with ever-increasing temperatures and decreasing water resources, our ability to mitigate effectively for natural hazards, respond to climate changes, and manage our common resources becomes ever more critical. The GETSI project is rooting the study of earth science through the lens of societally important questions. The aim is to increase students’ (future citizens’) ability to analyze and address these challenges.

**Changes/Problems**

**Actual or Anticipated problems or delays and actions or plans to resolve them**

The final publication of the modules has been a little later than we originally intended. No new actions or plans are needed to resolve the delay. We completed the original plan but on a somewhat extended schedule.
Appendix – Report from External Evaluator

Final Evaluation Report
Prepared for GETSI by
Ellen Iverson, Director of Evaluation
Science Education Resource Center (SERC) at Carleton College

Summary and Logic Model

A. INPUTS

| NSF Funding | UNAVCO | TUES partner colleges, universities, and faculty | SERC | NAGT Geodesy community | Earth science teaching community feedback |

B. OVERARCHING OBJECTIVES

1. Improve geoscience (particularly geodetic) knowledge base of undergraduate students both for general science literacy (introductory) and future science workforce (majors-level).
2. Improve effectiveness of teaching resources and pedagogy employed by faculty members teaching geodesy, geoscience, and allied sciences.

C. TUES TYPE 1 OUTPUTS

1. Development, testing, revision, and dissemination of four curricular modules featuring geodesy data investigations which support Earth science and quantitative literacy at both introductory and majors’ levels in diverse academic settings.
2. Developers’ manual to facilitate future integration of geodesy and other data into teaching materials.
3. Support for faculty in integrating curriculum into courses.

D. TUES TYPE 1 OUTCOMES

1. Students:
   a. Are able to apply authentic geodetic data and quantitative reasoning to addressing critical societal issues
   b. Have improved understanding of nature and methods of science
   c. Gain better understanding of relevant geoscience and climate literacies (Table 1) and the ability to apply them to critical resource, hazard, and environmental issues
2. Faculty:
   a. Adopt developed geodesy curriculum modules
   b. Include more connections between authentic data and addressing of critical societal issues
   c. Increase use of promising pedagogical practices in STEM education (e.g., Freyd, 2008)
   c. Use systematic assessment of student learning

E. LONG TERM OUTPUTS

1. Development, testing, revision, and publication of a larger collection of curricular modules featuring geodesy.
2. Support faculty in integrating curriculum into diverse institutions and course settings across the USA.

Figure 1 GETSI Logic Model

The logic model (figure 1) outlined in the proposal guided work on this project. Overall, the project met or exceeded its goals in outputs, outcomes, and long term outputs through ongoing community engagement. This evaluation report summarizes four years of evaluation progress and findings for the GETSI Geodesy Tools for Societal Issues project. In addition to meeting the outputs and outcomes, two areas of success are worth noting: 1) This project prioritized community engagement early and throughout its timeline. Early indicators from web usage, webinar attendance, and faculty requests for instructor materials demonstrate remarkable success in a short period of time and 2) This project provided a proof of concept of adapting a materials development process and design rubric from another geoscience NSF project (InTeGrate) successfully. It demonstrates how collaboration across NSF funded projects can yield to products that are of high quality and use to impact faculty teaching and student learning.
Engaging the Broader Community

The project met its intended goals of both engaging the community early in the project and connecting back to the community with support for integrating new geodetic materials in their courses.

Early Community Engagement Events

In the first year of the project, Dr. Beth Pratt-Sitaula facilitated two webinars for the 25 faculty who applied to be part of a virtual dialogue about geodesy teaching resources. The end of event survey indicated high satisfaction with the webinar (8.9 out of 10). The participants of the webinars indicated that teaching resources that integrated geodetic data would be valued in introductory and majors courses.

Final and Ongoing Community Engagement

In this final year of the project, Project leadership continued to engage the broader community with the completed materials. Event efforts have included webinars (via the InTeGrate webinar series) and a short-course at AGU (see Table 1). These efforts connected with the community both synchronously and asynchronously via the website.

Table 1 Community Engagement Event Measures

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<tr>
<th>Engagement product</th>
<th>Engagement Measures</th>
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<tr>
<td>Using Data to Teach about Societally Important Questions, offered on March 23, 2016 which featured GETSI Ice Mass and Sea Level Changes module along with InTeGrate Earth Modeling module.</td>
<td>• 82 registered participants&lt;br&gt;• 39 participated in scheduled discussion&lt;br&gt;• 12 completed end of event survey reporting high satisfaction (9.2 out of 10)&lt;br&gt;• 560 users (to date) viewed the webinar page</td>
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<tr>
<td>Webinar: Addressing Water Resources and Sustainability in Upper-level Undergraduate Courses, offered October 6, 2016. Webinar highlighted teaching strategies and examples that help students consider water resources and sustainability using real data</td>
<td>• 83 registered participants&lt;br&gt;• 28 participated in scheduled discussion hour&lt;br&gt;• 18 completed end of event survey reporting high satisfaction (9.1 out of 10)&lt;br&gt;• 252 users (to date) viewed the webinar page</td>
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<tr>
<td>Webinar: Addressing Earthquake Hazards with LiDAR, GPS, and InSAR in Upper-level Undergraduate courses, offered April 13, 2017. Webinar featured two modules intended for upper-level geoscience courses that feature learning about active tectonics through these geodetic methods and motivated by improved societal preparedness for earthquakes</td>
<td>• 122 registered participants&lt;br&gt;• 50 participated in scheduled discussion hour&lt;br&gt;• 11 completed end of event survey reporting high satisfaction (8.5 out of 10)&lt;br&gt;• 489 users (to date) viewed the webinar page</td>
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<tr>
<td>AGU Short Course on December 11, 2016</td>
<td>• 33 participants</td>
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gave instructors hands-on experience with curricular modules that feature LiDAR, InSAR, GPS, and structure from motion (SfM) photogrammetry data and methods for both classroom and field courses.

The website usage has continued to grow (see Table 2) with overall 4,753 unique users. In addition, 46 faculty have requested access to the password protected instructor materials, a particularly powerful measure of planned use in specific courses.

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<th>Table 2 Website Usage</th>
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<tr>
<td>Pageviews</td>
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<tr>
<td>January – December 2015</td>
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<td>January – December 2016</td>
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<td>January 2015 to May 2017</td>
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Outputs and Outcomes

Materials Developed

As proposed the project produced a Developers Manual webpage and Curriculum Modules. The original proposal had identified two introductory and two majors’ modules. The project actually produced five modules with an additional majors’ module.

Developers manual. A webpage that describes key elements, design steps, and lessons learned in the GETSI materials development. The page has had modest use (64 unique pageviews). While the original manual was envisioned to include case stories, the instructor stories are now included as part of the teaching materials which has received more significant web usage.

Module development. As proposed the materials successfully adapted the InTeGrate Step Center process and design rubric. Face-to-face kick off workshops were instrumental in the development of 4 of the 5 modules. The workshops provided a venue to establish working relationships, define timelines and communication plans, review processes, and begin module development. Pratt-Sitaula and either Iverson or the assessment consultant, Dr. Stuart Birnbaum, reviewed the materials against the design rubric prior to pilot testing. The rubric was critical in providing feedback to the module authors on areas of concern. This led to high quality materials prior to field testing.

Student outcomes. The Year 1 modules were piloted in 6 courses, involving over 113 enrolled students. The Year 2 modules were piloted in 8 courses, involving over 140 enrolled students. Summative assessments of student work was sampled across the three field sites for each module. These assessments were scored by Pratt-Sitaula and either Iverson or Birnbaum, using a rubric that identified to what extent the student work met the goals of the module and exhibited the guiding principles of the GETSI project. Pratt-Sitaula used the results of the
scoring of student work to inform the revision plans for the module authors. This ensured that the finished materials included assessments where students would be able to demonstrate successful learning aligned to the learning goals of the module.

**Faculty reflections.** A faculty reflection survey was received by five of the faculty who had authored materials. Faculty reported challenges in managing development schedules with team members at different institutions who had different competing demands. Faculty also reported how excited they were about the completed materials. Three faculty (non-authors) also completed a reflection about their use of the materials in their course. They reported on how the materials was used, what aspects of worked well and which were challenging in their course. The specific comments related to the module were useful in revision of the materials. One overarching theme across these field testers rested in the challenges students had in communicated about the data.