

The Role of UNAVCO in Geodesy and Field Education

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Summary

At universities across the country there is growing demand for integration of technology into geoscience field education settings, and increased interest in the use of geodesy in field education. UNAVCO community members have identified areas in which there is demand for ancillary support of these activities. Three primary recommendations for UNAVCO contributions to field education support are put forward. These community recommendations are the collective findings of an online survey and a two-day input-gathering workshop:

1. Increase the visibility of field education services available from UNAVCO.
2. Provide professional development for technical and pedagogical aspects of field education.
3. Make existing and new resources available to the community via online pathways.

Specific resources identified by the community include:

- Staffing for field engineering support in education settings,
- Support for curricular material development and implementation,
- Equipment prioritized for field education, and
- Resources to make computing & data analysis tractable in field education.

Introduction & Motivation

Fieldwork is an integral part of the geosciences and there is a longstanding tradition of teaching field methods as part of the geoscience undergraduate curriculum. As new technology changes the ways in which we scientifically examine Earth, and as workforce development demands evolve, there is growing interest in introducing these technologies into field education curricula. Geodetic technologies common to modern research and industry studies include static and real time kinematic (RTK) surveying and point positioning, using either the global navigation satellite system (GNSS) or global positioning system (GPS); Terrestrial, Airborne, and Mobile Laser Scanning (TLS, ALS, MLS [based on lidar – light detection and ranging – technology]); satellite and terrestrial-based interferometric radar, and photogrammetry. UNAVCO, through management of the National Science Foundation's (NSF) geodetic facility (GAGE: Geodesy Advancing Geosciences and EarthScope) has over 30 years experience providing such technologies in

support of scientific advancement. UNAVCO also has a long track record of facilitating professional development for graduate students, post-doctoral researchers, and faculty through technical short courses focused on geodetic technologies supported by UNAVCO.

Educators have also begun to introduce these technologies, and the datasets they generate, into classroom and field education settings (Douglas, 2012). Over the past five years UNAVCO has been working with faculty from a variety of institutions to bring TLS and RTK GPS into field camps and seminar courses (Crosby, et al., 2013). In recent years the demand for education and outreach support for field education has increased substantially. A recommendation from the *Community Workshop: Charting the Future of Terrestrial Laser Scanning (TLS) in the Earth Sciences and Related Fields* (Phillips et al., 2012a & b) was that UNAVCO engage in multiple levels of education and outreach in field education. However, there are challenges associated with implementing TLS, RTK and other geodetic techniques and their associated data in an educational setting. Computing resources, data volume, limited hardware resources, and the need for trained staff to operate the equipment all must be addressed.

Thus, there is growing need for a comprehensive approach to incorporate UNAVCO-supported geodetic technologies into university courses and field camps (here collectively referred to as “field education”). This report catalogs the collected community input on scoping and resourcing this effort. In particular, potential efforts include:

- UNAVCO engineering staff support during field education,
- Use of UNAVCO-owned equipment,
- Education Specialist support pre-, post-, or during the field education,
- Development and support for an online repository of educational materials and resources for field education activities, and
- Short courses for faculty to gain experience with technologies before using them in field education.

GNSS/GPS

Geodetic survey technologies such as static and RTK GNSS/GPS surveys are common in the research community. These tools are used alone (e.g., landslide monitoring, geomorphic analysis of fault scarps, channel geometries, or river terraces) or in tandem with other geophysical sampling methods (e.g., gravity, seismic, TLS). Although some universities have RTK GPS systems and the expertise to utilize them, many do not. UNAVCO has a large pool of GPS equipment, and expert field engineering staff trained to deploy and operate the instruments. UNAVCO has provided GPS field education support to one field education course for 5 years.

Geodetic Imaging

Geodetic imaging technologies (TLS, ALS, MLS, Structure from Motion, terrestrial radar) have emerged as critical tools for a range of earth science research applications from high quality base maps to change detection to stratigraphic sequence analysis (Miller et al., 2009). UNAVCO has supported 15 field education courses through 6 different institutions over the last 5 years. (<http://www.indiana.edu/~sierra/> and <http://www.indiana.edu/~iugfs/courses/g429.html>).

Gathering Community Input

Input from the UNAVCO community on the role of UNAVCO in support of field education activities was solicited. Contributions were gathered via a 2-day workshop and an online survey. The workshop was held at UNAVCO Headquarters, in Boulder, Colorado, on November 17-18, 2014. Participation was encouraged through a community announcement and advertising at the Geological Society of America (GSA) annual meeting. Twenty-one community members participated. Broader input was collected through a survey distributed to both the UNAVCO and the broader field education communities. A total of 67 people completed the survey.

Field Education Geodesy Workshop – November 17-18, 2014

The goal of the workshop was to bring together educators who are interested in, or are already actively using, geodetic techniques in a field education context to provide recommendations for future UNAVCO efforts in this realm. Faculty currently utilizing geodetic technologies presented their curriculum and lessons learned. The group discussed challenges, best practices, and how to optimize the student experience. Finally, participants discussed next steps and outlined recommendations to UNAVCO on how to best support field education and teaching resource needs going forward.

Workshop logistics and participant support were provided by UNAVCO. The following individuals convened the workshop:

- Bruce Douglas, University of Indiana
- Nathan Niemi, University of Michigan
- Bob Wang, University of Houston
- Donna Charlevoix, UNAVCO
- Christopher Crosby, UNAVCO
- Beth Pratt-Sitaula, UNAVCO

Important contributions were provided through invited presentations by:

- Jeff Ryan, University of South Florida – Broader impacts of field education
- David Mogk, Montana State University – Best practices in field education
- Deidre Lamb, University of Arizona – Engaging students with disabilities

The majority of workshop participants were university faculty (Table 1). The professionals and graduate students in attendance were either actively working with a faculty member or anticipated being in a faculty position in the near future.

Table 1. Participants in the November workshop by audience type.

Audience	# Participants
University Faculty	18
Post-doctoral Professionals	1
Other Professionals	1
Graduate Students	1
TOTAL	21

In addition to talks by conveners and invitees, eight other participants gave short talks on their experiences and future plans (full agenda in Appendix A). Workshop participants were selected from an applicant pool with priority given to UNAVCO community members who have leveraged instrumentation for field courses in the past, community members interested in integrating geodetic technologies into their courses, and non-UNAVCO community members who either use or are planning to use geodetic technologies in class (participant list in Appendix B).

Community Survey – October-December 2014

A survey designed to gather information from instructors was widely distributed both online and via paper. Input was sought from both the UNAVCO and broader geosciences communities through: 1) the UNAVCO community email list-serve and several field education email list-serves; 2) Social media (Facebook, Twitter) of UNAVCO, and Open Topography; 3) in-person interactions at the GSA 2014 Annual Meeting and American Geophysical Union (AGU) 2014 Fall Meeting. Sixty-seven instructors responded to the survey in total (survey questions in Appendix C).

The survey respondents were overall quite interested in the integration of geodetic techniques into their field courses (detailed results in Appendix D). There was strongest interest in GPS technologies (52% high interest and 28% some interest for RTK GPS) but also robust interest in lidar (42% high, 52% some) and photogrammetry (45% high, 41% some). Although support from UNAVCO in the form of engineering or educational specialist was certainly welcomed, the majority of respondents showed strong preference for ultimately achieving independence on geodetic methods. Over 60% were highly interested in short courses for faculty to learn geodetic techniques and in online field course curricula.

Of the 67 survey respondents, 69% were from MS/PhD-granting institutions, 24% from 4-year schools, and 6% were community college faculty. The average knowledge of field geodesy was 3.8 (on a scale of 1=no knowledge and 5=I am a geodesist), indicating that most people were fairly familiar with geodetic techniques, but not experts). Forty-five percent of respondents taught a multi-week field “camp”, while 1- and 2-day field experiences were each taught by approximately 32% of respondents. Over 70% of respondents teach late-stage earth science majors but field experiences for early-stage majors or graduate students each rank about 40% (total can be more than 100% because many instructors teach multiple kinds of field courses). Solid earth topics dominated the field teaching interests of the respondents, which were heavily weighted towards structural geology (52%), tectonics (48%), geomorphology (44%), and geophysics (41%) but teaching interests in the cryosphere, environmental sciences, hydrogeology, and volcanology were also reported by 10 to 20% of the respondents. The results were also tabulated by field course duration, type of institution, and subject area. However, the key findings did not change notably between different subsets of the population. The overarching results are that 1) GPS, TLS, and photogrammetry were all technologies of interest for inclusion in field education, with GPS being somewhat preferred over the others, and 2) the strongest interest was in ultimately having teaching independence achieved through training via short courses and online curriculum.

Findings and Recommendations

Three primary recommendations for UNAVCO field education support emerged. The recommendations are the collective findings of the online survey and workshop activities. These include increasing the visibility of field education services available from UNAVCO, providing professional development, and making existing and new resources available to the community. Specific UNAVCO resources identified include staffing for both field engineering and education support, support for curricular materials, equipment prioritized for field education use, and resources to make computing & data analysis tractable in field education.

Visibility of services. UNAVCO should increase visibility of products and services as they relate to field education. Online access to resources and materials should be readily available. Create a dedicated space on the UNAVCO website with information for faculty interested in leveraging UNAVCO support for their field education activities. Online content should include fact sheets on instrumentation use, case studies of successful deployments, general introductory geodetic curriculum for wide adoption, generalized geodetic field exercises for education, and examples of alternate plans in cases of insurmountable technical difficulties. Assessment tools and guidance for evaluating effectiveness and impact of field-based use of geodetic equipment should be available.

Project support for field education should be formalized and parallel the UNAVCO science Project Support Request process. The intent is to ensure instructors requesting field education support have the tools and information regarding implementation and assessment to be successful. Support request should include information about the instructional strategy to be used, implementation plan, and an assessment plan to evaluate impact.

Professional Development. Several areas of training and professional development should be considered. UNAVCO should develop and offer training courses for including geodetic data acquisition in educational settings, principally through workshops and short courses. Video tutorials are of secondary importance. Provide technical training for operating equipment and for developing curriculum elements based on geodetic data acquisition. Offer short courses for instructors focused on data processing and analysis for educational purposes.

Resources. UNAVCO should provide community field education resources in four areas to ensure the greatest return on investment. These include: staffing resources, curricular resources, equipment resources for education purposes, and computing and data products. UNAVCO should prioritize the identification of a pool of equipment for educational use and the associated resources needed to support that equipment in the field for educational purposes.

Staffing resources. UNAVCO should provide staff support upon request to ensure successful field experiences. Field engineers may be needed for equipment set up, troubleshooting, or data processing in the field. Education staff support may be needed before, during or after the field camp to adapt materials and assessments to the particular field experience.

Curricular resources. Curricular resources include those for student engagement as well as documentation of how to use equipment in an educational setting. How-to manuals exist and should be refined and differentiated for different types of equipment or methods of usage in the field. Pre-created activity sheets for students with worked examples of educational outputs should be available for adoption or adaptation in the field. The identification of existing field site “hot spots” can be used as a framework for similar field education activities. Example: An instruction-oriented case study-based lessons & data could be made available for download for classroom or field camp use. This would be beneficial to instructors who do not have access to a field site exemplifying the conditions to be investigated or if time or resources are a constraint that prohibit field work. Leveraging existing data sets collected by other field courses could allow students who wouldn’t otherwise have access to the field the opportunity to explore a student-collected geodetic dataset and apply the same techniques for geodetic data analysis and interpretation.

Equipment resources. Instrumentation prioritized for field education should be available including RTK (cellular enabled) GPS, TLS, and Structure from Motion (from UAV or other mobile platform). Formalize and scale the clearinghouse model for sharable resources to serve a broad community of users. Instrumentation and equipment available would include TLS, RTK/GPS, laptops & software, and associated accessories (e.g. targets; tripods).

Computing and data resources. Computing resources in a field camp setting can be especially challenging given rural settings and limited bandwidth. UNAVCO should consider a pool of mobile computers and software for use in field education. Data processing for educational purposes could be improved with better access to simplified software for geodetic/GPS processing. Students and instructors would benefit both from easily digested higher order TLS products for distribution and compilation of existing datasets including TLS and airborne laser swath mapping (ALSM) via an existing NSF investment such as OpenTopography.

Other Community Suggestions

UNAVCO should continue to engage the community to identify priorities for integration of geodetic technologies into education. This is an important mandate as technology, equipment, and educational best practices continue to evolve. UNAVCO is well positioned to coordinate community stakeholders to secure dedicated funding to support education-specific resources for incorporation of geodetic instrumentation and data into field education.

References

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- Douglas, B., (2012), Integration of Terrestrial Laser Scanning (TLS) within a traditional geologic field course: Insights from the Indiana University G429 Program, Invited Presentation – UNAVCO Science Workshop February 2012. Accessed 24 January 2015, <http://www.unavco.org/community/meetings-events/2012/sciworkshop12/coming-soon.html>
- Phillips, D. A., J. S. Oldow and J. D. Walker, (2012a), Outlining a strategic vision for terrestrial geodetic imaging, Eos Trans. AGU, 93(11), 121.
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- Miller, M. M., C. Meertens, D. Phillips, C. Rubin, L. Ely, and B. Pratt-Sitaula, (2009), Collaborative Research MRI: Acquisition of Terrestrial Laser Scanning Systems for Earth Science Research, Submitted to EAR Major Research Instrumentation, 22 January 2009. Accessed 24 January, 2015, http://www.unavco.org/community/publications_and_reports/proposals/proposals.html

Appendix A: Workshop Agenda

Field Education and Support by the UNAVCO GAGE Facility

UNAVCO, 6350 Nautilus Drive, Boulder, Colorado

November 17-18, 2014

Monday, November 17

8:10 *Meet in hotel lobby for travel to UNAVCO*

8:30 *Arrive at UNAVCO; breakfast*

9:00 Introduction to the workshop; welcome from M. Miller, UNAVCO president

9:05 Group introductions

9:30 Overview of UNAVCO, workshop goals, and objectives (D. Charlevoix)

9:50 Introduction to UNAVCO field support, equipment, geodetic imaging and field education (C. Crosby)

10:10 Importance of field education, research, broader impacts (J. Ryan)

10:30 Field education and best practices (D. Mogk)

10:50 *Break*

Current GPS/TLS Field Educational Programs Supported by UNAVCO

11:10 Bruce Douglas (IU): *TLS at the IUGFS field camp*

11:30 Nathan Niemi (U. Michigan): *TLS at U. Michigan field camp*

11:50 Bob Wang (UH): *GPS and LIDAR Education at UH*

12:15 *Lunch*

Current field educational programs (imaging and GPS)

1:00 Katie Kumamoto (Stanford): *Lasers on Landscape: Setting up a TLS field course at Stanford*

1:20 Beth Bartel (UNAVCO, for Michael Hamburger (IU)): *GPS at the Indiana University Sierra field class*

1:40 D Sarah Stamps (UCLA): *Field Methods for High Precision GPS Measurements: lessons from 3 short-courses in Africa*

2:00 Breakout session: What are successes, challenges and existing complimentary materials for field education using geodetic technologies? (with a focus on the technologies discussed in the presentations)

2:45 *Break (in kitchen)*

3:00 *UNAVCO Facility tour and group photo*

Current field educational programs continued (GPS and GIS-based mapping)

3:30 Tina Niemi (UMKC): *Using RTK GPS and developing tablet fieldbooks for undergraduate research*

3:45 Jeff Snyder (BGSU): *Integrating GPS/GIS-Based Mapping in a Mobile Five-Week Field Geology Course Taught in New Mexico and Colorado*

4:00 Ben Crosby (ISU): *Finding a Home for Technology in a Traditional Geology Field Camp: Lessons from Idaho's Lost River Field Station*

- 4:15 Breakout session: What are successes, challenges and existing complimentary materials for field education using geodetic technologies? (with a focus on the technologies discussed in the presentations)
 - 5:00 Group report out
 - 5:20 Wrap up, goals for Day 2
 - 5:40 *Return to hotel*
 - 6:30 *Dinner at Oskar Blues, Longmont*
-

Tuesday, November 18

- 8:10 *Meet in hotel lobby for travel to UNAVCO*
- 8:30 *Arrive at UNAVCO; breakfast*
- 9:00 Recap of Monday, agenda and goals for today (D. Charlevoix)

Looking forward: program development

- 9:15 Karl Kreutz (U. Maine): *Field education in Alaska and REU planning*
- 9:30 Diedre Lamb (U. Arizona): *Accessibility issues, inside and outside the classroom*
- 9:45 Rick Bennett (U. Arizona): *Experiences developing an accessible field trip to the Grand Canyon*
- 10:00 Breakout Discussion: What can UNAVCO do to better support field education in the areas of: 1) equipment and technical support, 2) staffing support and training, 3) curriculum materials and online resources.
- 10:45 *Break*
- 11:00 Breakout Discussion continued.
- 11:45 Reports from breakout & discussion
- 12:15 *Lunch*
- 1:15 Final breakouts & generation of preliminary set of community recommendations to UNAVCO
- 2:15 Report out
- 2:45 Workshop wrap up, next steps
- 3:00 *Workshop adjourns*

Appendix B: Workshop Participants

First Name	Last Name	Institution
Carlos	Aiken	University of Texas, Dallas
Rick	Bennett	University of Arizona
Michael	Bunds	Utah Valley University
Benjamin	Crosby	Idaho State University
Kenneth	Hughes	University of Puerto Rico
Karl	Kreutz	University of Maine
Kathryn	Kumamoto	Stanford University
Diedre	Lamb	University of Arizona
Rocco	Malservisi	University of South Florida
Keith	Milam	Ohio University
David	Mogk	Montana State University
Amit	Mushkin	University of Washington
Nathan	Niemi	University of Michigan
Tina	Niemi	University of Missouri-Kansas City
Jeffrey	Ryan	University of South Florida
Jeffrey	Snyder	Bowling Green State University
D. Sarah	Stamps	Massachusetts Institute of Technology
Guoquan	Wang	University of Houston
Lucas	Ward	Rocky Mountain College
John	Weber	Grand Valley State University
Bruce	Douglas	Indiana University
Beth	Bartel	UNAVCO
Chris	Crosby	UNAVCO
Donna	Charlevoix	UNAVCO
Marianne	Okal	UNAVCO
Beth	Pratt-Sitaula	UNAVCO



Appendix C: Community Survey Questions

This is the paper version but the same questions were also available on Survey Monkey.



Geodesy Field Education Support – Instructor Input Survey

Fieldwork is an integral part of the geosciences and there is a longstanding tradition of teaching field methods as part of the undergraduate curriculum. As the technologies for scientific examination of Earth have grown, there is more interest in introducing these technologies into field education curriculum. UNAVCO, which runs the National Science Foundation's geodetic facility, is looking for community input on how best to support field instruction using technologies such as GNSS/GPS and geodetic imaging (ex. laser scanning and photogrammetry).

If you teach any sort of field work, please help these efforts by taking this short survey.

1. At what type of institution do you teach?
☐ 2-year college
☐ 4-year college (no grad program)
☐ MS or PhD-granting university
☐ Other _____
2. Please rate your knowledge of geodetic field methods on a 5-point scale.
☐ 1 = Very unfamiliar (Geodesy? What's that?)
☐ 2
☐ 3 = Somewhat familiar (I know something about it or mention it in courses)
☐ 4
☐ 5 = Extremely familiar (I have used geodetic method/s in my field course)
3. What duration of fieldwork does your course have? (check all that apply)
☐ Half or 1-day field experience/s
☐ Weekend field experience/s
☐ Week-long field experience
☐ Multi-week field "camp"
☐ I have not yet taught a field course but plan to do so
☐ Other _____
4. What is the primary audience of your field course? (check all that apply)
☐ Non-earth science majors
☐ Early-stage earth science majors
☐ Late-stage earth science majors
☐ Graduate students
☐ Other _____
5. In what disciplines do you teach fieldwork? (check all that apply)

<input type="checkbox"/> Cryosphere/climate change	<input type="checkbox"/> Hydrogeology
<input type="checkbox"/> Environmental Science	<input type="checkbox"/> Structural Geology
<input type="checkbox"/> Geodesy/Geophysics	<input type="checkbox"/> Tectonics
<input type="checkbox"/> Geomorphology	<input type="checkbox"/> Volcanology

Other/s _____

6. For each of the following geodetic technologies, please rate your potential interest in incorporating it into field course/s you teach (see Fig. 1 & 2 for details on geodetic methods)

Circle the best answer for each application

	<u>Interest</u>		
a. Static GPS/GNSS	High	Some	No
b. Real time kinematic (RTK) GPS/GNSS	High	Some	No
c. Airborne laser (lidar) scanning (ALS)	High	Some	No
d. Terrestrial or mobile laser (lidar) scanning (TLS/MLS)	High	Some	No
e. Photogrammetry (ex. Structure from Motion (SfM))	High	Some	No
f. Other _____			

7. For each of the following types of support, which UNAVCO could offer, please rate your potential interest.

Circle the best answer for each application

	<u>Interest</u>		
a. Technical Engineering support during the instruction	High	Some	No
b. Educational Specialist support pre-, during, or post-instruction	High	Some	No
c. Short courses for faculty to gain experience prior to teaching	High	Some	No
d. Development of field course curriculum available online	High	Some	No

Other comments or suggestions?

THANK YOU SO MUCH FOR YOUR TIME

If you would be willing to be contacted by the survey authors regarding follow-up questions or would like access to early release of materials, please provide name and contact information.

Name _____ Phone/email _____



***Please give the survey to a UNAVCO staff member
or drop it by the UNAVCO booth in the exhibit hall.***

Figures associated with community survey

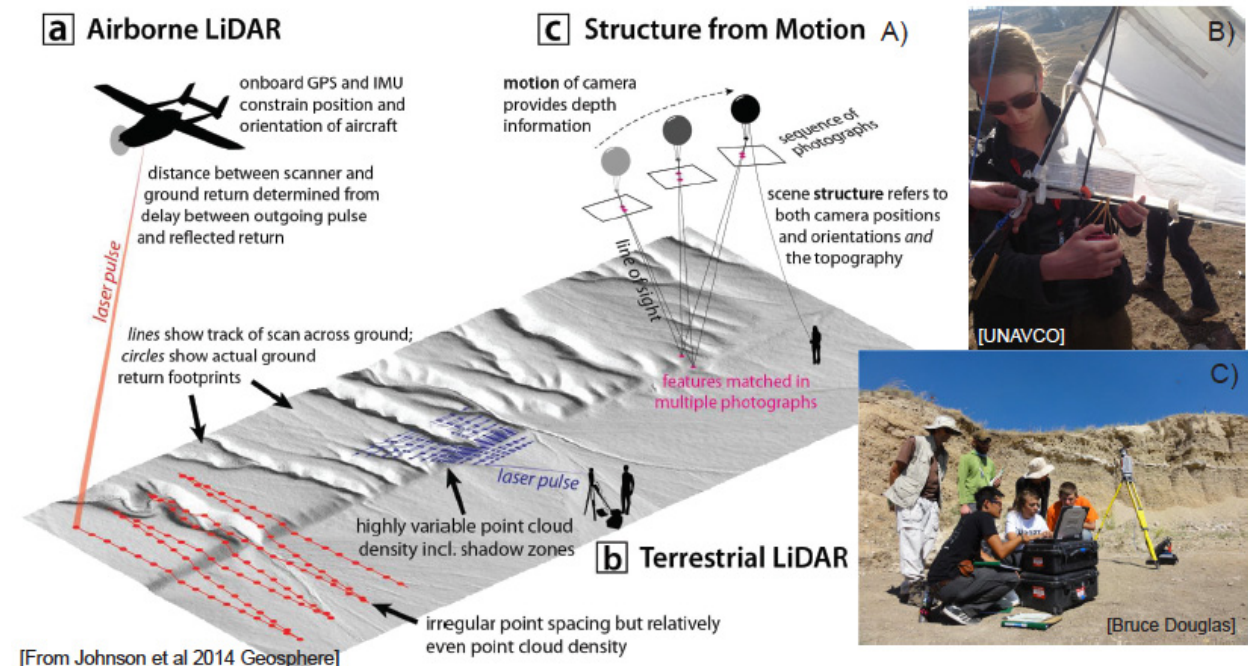


Figure 1. A) Three methods for generating high resolution topography. Airborne LiDAR is increasingly used for field work base maps. Terrestrial laser scanning (TLS) has been used in field courses for erosion, fault scarp, and stratigraphic analyses among others. Structure from Motion (SfM) can provide fast and affordable imagery in certain open field environments; B) affixing a camera to a helium balloon for SfM; C) students in Montana run a TLS survey.

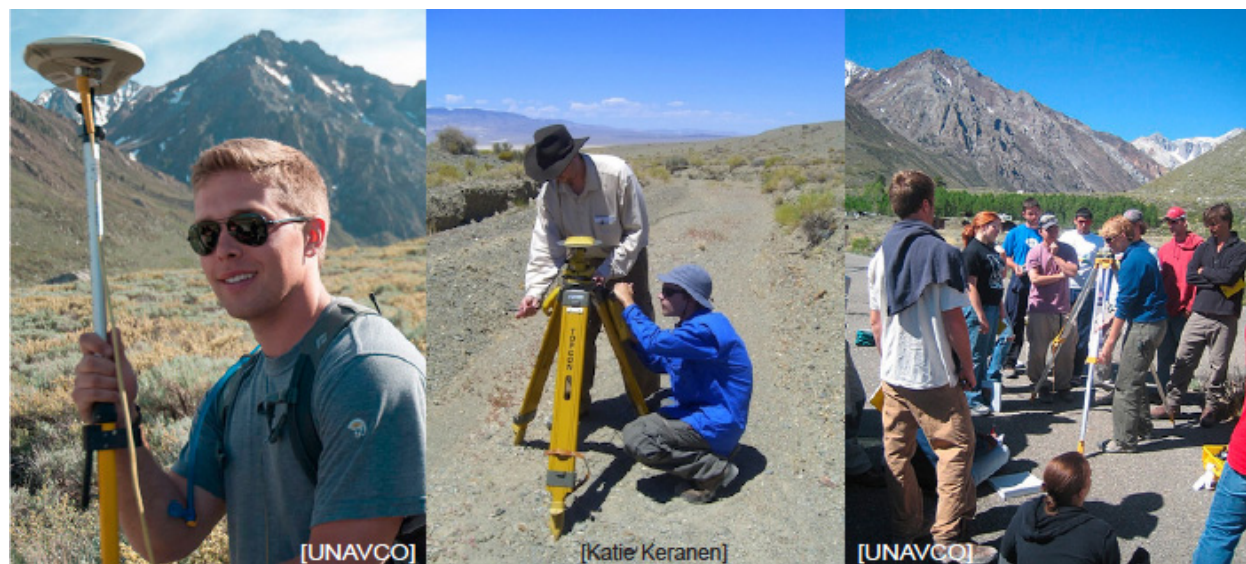
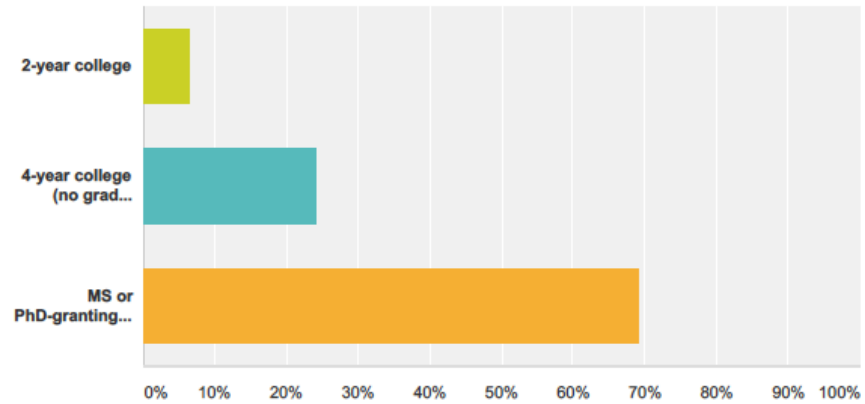


Figure 2. Students learning how to conduct GPS/GNSS surveys. Both static and real time kinematic (RTK) have been used in field courses. These methods can be applied to topics ranging from geomorphic analysis to volcanic monitoring, as well as provide supporting data for gravity, seismic, or TLS projects.

Appendix D: Community Survey Full Results

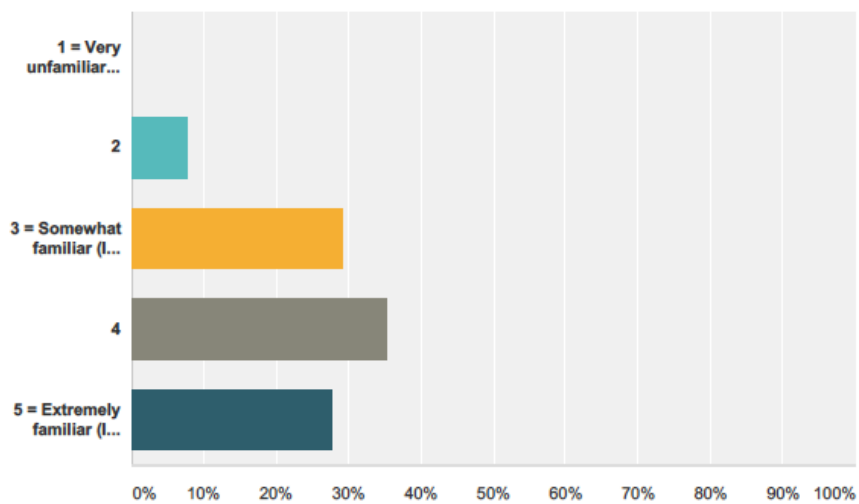
Q1 At what type of institution do you teach?

Answered: 62 Skipped: 5



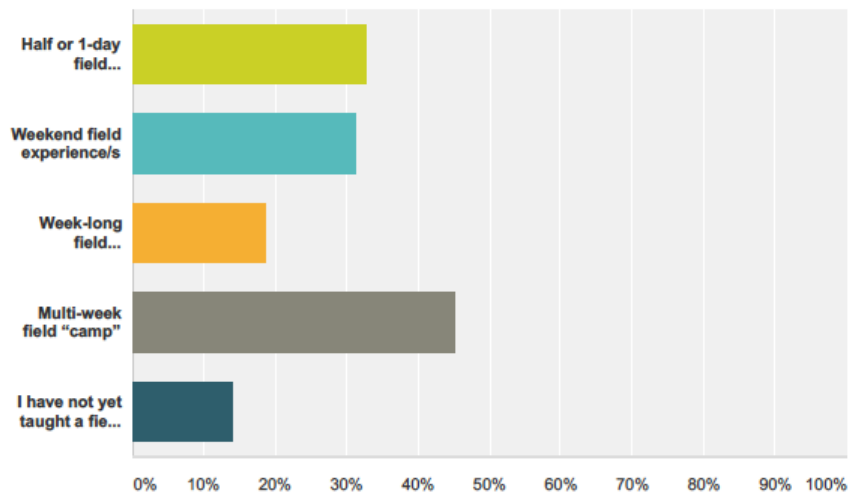
Q2 Please rate your knowledge of geodetic field methods on a 5-point scale.

Answered: 65 Skipped: 2



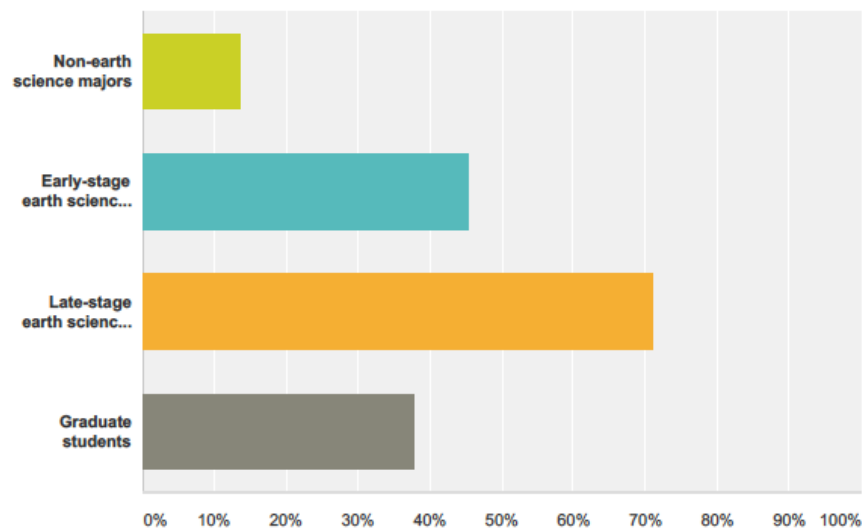
Q3 What duration of fieldwork does your course have? (check all that apply)

Answered: 64 Skipped: 3



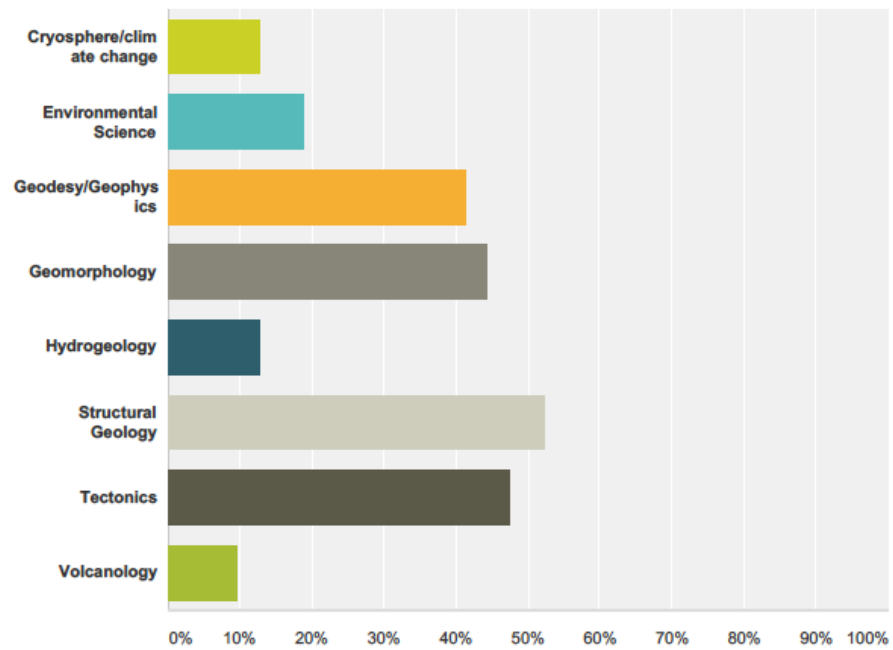
Q4 What is the primary audience of your field course? (check all that apply)

Answered: 66 Skipped: 1



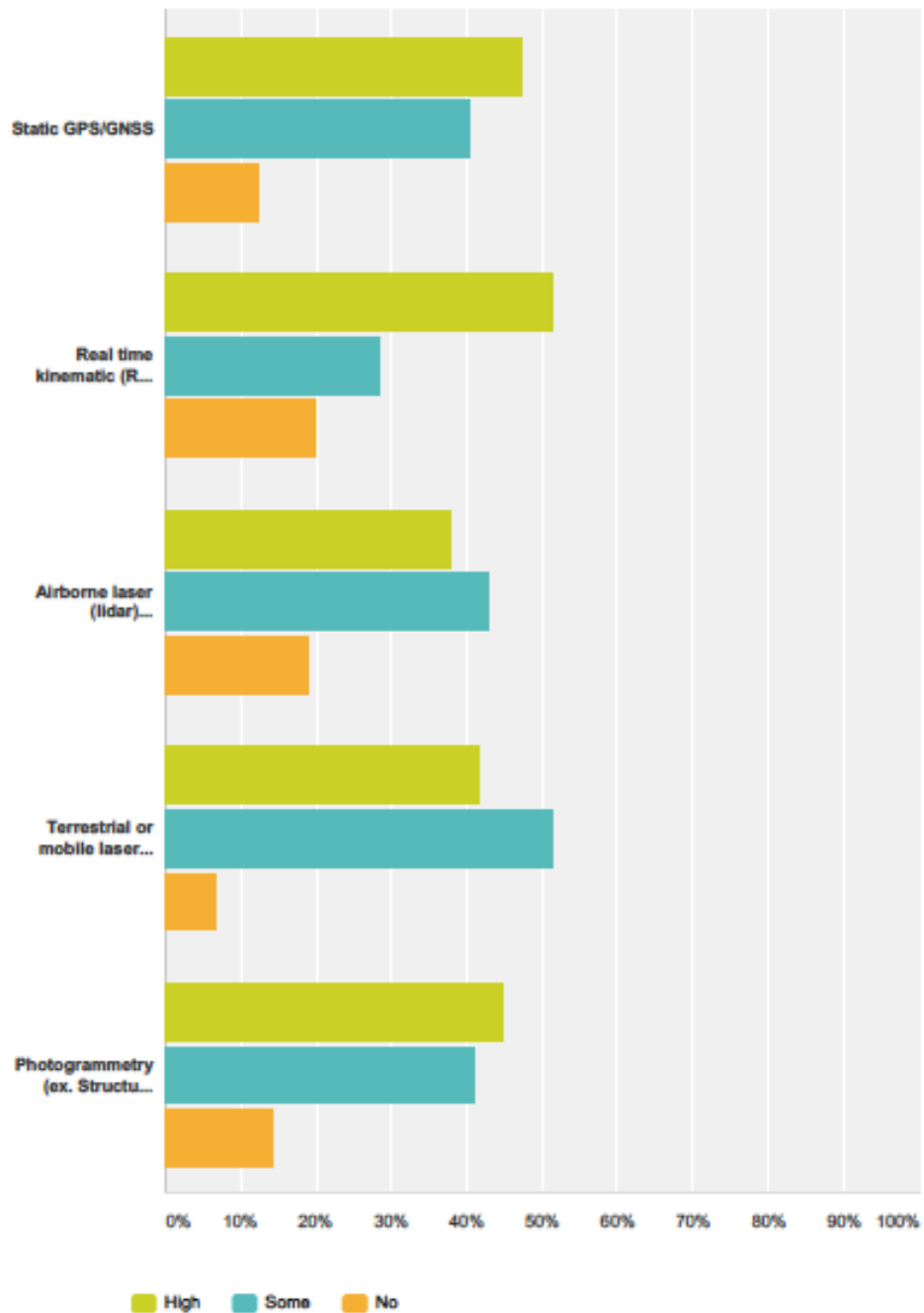
Q5 In what disciplines do you teach fieldwork? (check all that apply)

Answered: 63 Skipped: 4



Q6 For each of the following geodetic technologies, please rate your potential interest in incorporating it into field course/s you teach. Select the best answer for each application.

Answered: 60 Skipped: 7



Q7 For each of the following types of support, which UNAVCO could offer, please rate your potential interest. Select the best answer for each application

Answered: 60 Skipped: 7

