Future Directions and Priorities of Geoscience Education Research: Notes from Workshop Discussions
May 2016

This document is an outcome from the workshop, *Synthesizing Geoscience Education Research: Where are we? What is the path forward?* The workshop was held at the Earth Educators Rendezvous in Boulder, CO in July 2015.

This document summarizes the findings and results of group discussions at the workshop. The workshop organizers recognize these efforts to be an important first step in an ongoing process to summarize the current status of geoscience education research and prioritize future efforts.

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Wednesday, July 15, 2015 – Rotating Group Discussion

The final block of working time for the workshop was dedicated to looking toward the future of GER. Several different questions were posed, and each question was its own "station." Groups of workshop participants rotated through the stations. Each group visited three stations and spent 15-20 minutes contributing their thoughts to the topic. Each station had one facilitator/note-taker who stayed with the station throughout the session to provide consistency and compile the notes into a cohesive list.

The questions at each station are listed below:

- How should we better support those interested in becoming geoscience education researchers?
- What are priorities for promoting and supporting the GER research community?
- How should established GER workers develop their research skills? What tools do they need?
- How could we develop a "toolbox" for new GER workers?
- How can we infuse GER results into educational practices?
- What are the metrics of student success for geoscience majors?
- What are the metrics of student success for those taking general education courses in the geosciences?

For each question, the following bullets guided the discussion:

- What are the issues or concerns?
- Where would you like to be? (i.e., what is the goal for that issue?)
- What are ways to get there?

Participants were encouraged to focus on getting ideas on the table, rather than rehashing the problem. Participants engaged in discussion, creative brainstorming, and formulating a list of ideas,

next steps, and recommendations. The goal of the session was to come away with recommendations that represent the voice of the community (insofar as this is represented by workshop participants).

Synthesis

1. Definitions and roles

The geoscience education community benefits from the contributions of many types of professionals. As we define future efforts, it's helpful to understand and target the appropriate audience. We recognize that there is a spectrum of what the community means by "geoscience education research." The discipline spans the development and application of new geoscience teaching innovations and curricula, as well as the development and testing of geoscience education research questions and hypotheses. These can be characterized as the scholarship of geoscience teaching and learning (geo-SoTL), and geoscience discipline-based educational research (geo-DBER), respectively. Both SoTL and DBER are important for improving geoscience teaching practice.

Geoscience education researcher (geo-DBER)
People in this group are engaged in active educational research. They develop and test geoscience education research questions and hypotheses. They are well versed in the GER literature, and in other discipline-based educational research. They publish their research in education journals (e.g., JRST, JCST) and/or geoscience education journals (e.g., JGE).

Scholar of geoscience teaching and learning (geo-SoTL)
People in this group develop and apply new geoscience teaching innovation and curricula to their practice. They are well versed in the advancements of GER and uses them in their teaching practice. People in this group may read and publish curriculum and instruction papers in journals like JGE, attend or lead professional development workshops, and give presentations about their experiences with educational innovations and methods at conferences.

Geoscience educator/practitioner
Geoscience educators/practitioners are dedicated to teaching and student learning. They may or may not intentionally use research-based methods in their teaching practice, and who does not necessarily follow current developments in GER. Ultimately, these educators assist in carrying GER progress forward because they contribute to widespread adoption of improved teaching practices.

Each of these groups plays an important role in the overall development of the geoscience education community, and it's important not to suggest a hierarchy that one group is better than another.

2. Building and Strengthening our GER Community

2a. Career pathways and development

Facilitator not listed

One of the main take-away points from this sub-topic is that the career pathways into GER are currently not well defined. We can start out by understanding more about what the current pathways people are taking.

- Geoscience education researchers can have a degree in geoscience education or in a traditional geoscience discipline.
- It would be helpful to document the different strategies for entering the field a) as a graduate student, b) after graduate school, or c) from an already-established position.

Formally-trained in GER

- The growth in GER doctoral programs is interesting. We need to learn more about what the various curricula are like. Should there be a common experience for those in GER graduate programs?
- Identify the number of faculty positions in GER in the US.

Traditional geoscientists who shift into GER

- Pathways for traditionally trained geoscientists who want to engage in GER should be more clear (e.g., there is a need to define the most appropriate professional development path for those interested in migrating from traditional geoscience research to geoscience education research).
- It's important to clarify misconceptions about what geoscience education research is, so that those not inside the field can get an accurate sense of what it is. For example, GER includes social science, but this is no less rigorous than any other type of science research.

Important issues for both pathways

- Develop a national survey that tries to uncover how both formal and informal training supports future career success.
- Given the variability in the different ways people can enter into work in GER, professional mentoring may be particularly important.
- Newcomers to the field need to see what trajectory they could take to get involved in GER. We can give examples of different paths and outcomes. For example, information about GER could be included in Early Career workshops.

2b. Tools to Encourage Participation in GER

For educators and for those interested in getting started in research

These suggestions span a variety of approaches that would help explain what GER is, illuminate some basic tools, provide starting points to enter the field, and point the way to a larger community that is engaged in this work.

- Start out by recognizing these materials need to be designed for "consumers" who may not already be familiar with geoscience education. Thus we need an easy place where people can learn about the state of the field.
  Example from PER, *Getting Started in Physics Education Research* (http://www.compadre.org/per/per_reviews/volume2.cfm)
- Compile a list of key readings. For example, How People Learn (Bransford) - approachable theory, how learning works.
- Hold a series of webinars, workshops, or short courses. Specific topics could include introduction to theories in education, quantitative training, and statistics for social sciences.
- Design a bootcamp on GER, and/or a certificate program in GER with an on-line and face-to-face version.
- Write a book on GER research: a toolbox for researchers, a users guide. This could also be housed on the SERC website and build on existing resources there. (More info in the section below.)
  Example: *Nuts and Bolts of Chemical Education Research*
- Formalize Libarkin's early work/commentary in JGE on research methods, such as by compiling her columns into a web page.
- Encourage mentorship from people who hold different roles within the spectrum of GER (such as researcher or practitioner).
- Continue to emphasize and build this community through NAGT and other networks.
- Develop a network of leaders within NAGT-GER; people who are available for questions, references, or collaboration.
- Develop a community of practice, and be sure that activities happen at a regional scale in addition to larger, national meetings.

Resources that could be included in a toolbox:
(Facilitator: Julie Sexton)

- Information on what an IRB (institutional review board) is and when you need to do it?
- More information on what statistical analyses to do
- A list of the critical/important research articles to access
- List of best and most important papers that are cited
- List of databases used to find educational research
- List of important journals
- Set of successfully-funded NSF proposals for education research projects
- Set of external evaluation sections of successfully-funded projects
- List of external evaluators for NSF proposals

- List of conferences that are useful to attend
- List of professional organizations to know about and to join
- List of reliable and valid surveys to evaluate student outcomes and where to find them. Information on when to use the specific instruments.
- Set up a database of surveys and instruments
- List of JGE articles on science education research
- Resources to develop graduate students' knowledge of education research
- Resources for how to develop good research questions. What is a researchable topic and how to frame it into a meaningful question?
- Compile a list of the categories of geoscience education research showing the topics and areas that have been researched so that new people know what has been conducted. Could be in a concept map or a matrix – since there is likely to be overlap.
- Resource describing education research methodologies (quantitative, qualitative, mixed methods, action research) that are used and what are the strengths and limitations of those methods and designs
- List of the various email lists for geoscience education researchers
- Establish regional groups of geoscience education researchers who can work together
- Compile a list of GER people who could serve as speakers to visit institutions
- Question: Where should the toolbox be hosted and how should new people get introduced to knowing about the toolbox?
- A list of questions and topics for a geoscientist who wants to partner with a education/social science researcher can ask of that education/social science researcher to initiate a partnership
- A list of theoretical frameworks
- Develop a certificate for education research method and theories. A class on how to bridge the disciplines of the geoscience and the education fields (i.e., communication across the disciplines)
- Develop a resource describing how classroom practice could transition to education research.

2c. Building Awareness and Raising the Professional Profile of Geoscience Education Research

Facilitator: Laura Lukes

Publications

- Encourage publication of geoscience education research in a wider span of journals, in addition to JGE. For example, oceanography education research can be presented in an oceanography journal. Alternatively, education research could be submitted to a broad-interest publication such as *GSA Today*.
- In addition to submitting manuscripts, GER leaders can reach out to journal editors to engage them.
- Compile a list of publications that accept GER articles.

Departments and institutions

Not all colleagues, departments, and institutions recognize that GER is a legitimate avenue for research, comparable to traditional research topics. The GER community can help raise awareness of the value of their work and its legitimacy and rigor. Building awareness can happen at many scales (between colleagues, within departments, and throughout institutions).

- Successful grants can help illustrate the value of education research. These are models of success and it's worthwhile to make sure your department/dean have opportunities to notice this.
- Help departments recognize and value excellent teaching and curriculum development. Having curricular materials reviewed and published can demonstrate credibility and help build a case for promotion and tenure (P&T).
- Communicate the value of a peer-reviewed curriculum development process, such as offered by InTeGrate.
- Compile a list of external reviewers from the GER community who can help evaluate work done within GER. Faculty could give this list to department chair or committee. Try to get an external expert in GER on P&T committee.
- Outreach to department chairs: As part of AGU's Heads and Chairs workshop, include a session to inform department leaders about GER, its value, and ways to evaluate for P&T.
- NAGT-GER can help write letters of support and/or recognition for GER work in P and T.
- Explore possible alternative metrics for promotion and tenure (e.g., see how other DBER fields address P&T in science departments)
- Examine efforts in other science disciplines to help build support for education research within departments and institutions.

Across the whole community of geoscientists

- Form partnerships with industry. Link the goal of improved student learning to increased persistence, better preparation, and pathways to train and attract a more diverse workforce. (Example, spatial thinking and ExxonMobil and ConocoPhillips)
- A few leaders within GER could write an article in EOS and/of GSA Today emphasizing the value that education research brings to a department. A similar article could point out recent advances in GER and bring these to light for a wider audience.
- Try to get a GER leader on the GSA council to facilitate "top down" approaches to build awareness for and credibility of GER.
- Leverage the numbers. Gather the total amount of grant funding awarded in GER to show the impact and value. Similarly, compile the numbers of division members, sessions, and abstracts related to GER at GSA and AGU.

3. Supporting Forward Progress in Research

Facilitator: Anthony Feig

Workshop participants identified several tools and resources that would put needed resources in the hands of the researchers and help them plan their research design. Many of these ideas would serve to aggregate information that is currently dispersed across many different locations. These ideas do not require new information to implement; rather they require an initiative to aggregate materials into a clearinghouse for the research community.

- A series of **literature reviews** would help to show what has already been done and lay the groundwork for future work. Note that this suggestion has been implemented in the recent call for proposals for a JGE theme issue, *Synthesizing Results and Defining Future Directions of Geoscience Education Research*.
  Examples: Engineering (http://assess.tidee.org/search?sort=&q_0=inquiry&search_names=on&search_summaries=on&search_tags=on). Physics: (http://www.compadre.org/per/)
- A collection of different **instruments** would give researchers an overview of many different tools, with the advantages, disadvantages, and best uses of each one. This collection would be expected to grow and be refined over time.
  Example: ITEST program office.
- Different **research methods** could be aggregated into a collection that would describe the benefits of different types of research design and show examples of each. This would help guide researchers toward the methods best suited to their research goals. For example, what is the best way to design mixed methods studies? What is the best way to use qualitative data so that it is not viewed as anecdotal?
  Examples: *Nuts and Bolts of Chemical Education Research* and *Tools of Chemistry Education Research.* PER has a database of methods, but you need an account to see it
- A repository of **datasets** from previous research could help the community make better use of existing data. Ideally this would include results from the geosciences and other disciplines as well. This idea fits with NSF's data management requirements.
  Example: from psychology
- Understanding the **theoretical frameworks** surrounding research topics can be a challenge for physical scientists. But there is no need to learn in isolation. A Wiki-type website would provide a central resource for information about theoretical frameworks. It could contain relevant resources and a discussion group
- Community-wide support for **statistical analysis** would be very helpful. This could take the form of a stats "boot-camp," an online course or webinar series, short courses at professional meetings, or a warehouse of data that could be used to show examples of different types of analyses.
  Example: The ACS publication, *Tools of Chemistry Education Research*, contains several chapters on statistical methods.

- A **journal club** about research topics could provide ongoing support to those engaged in research. These clubs would want to leave a permanent record of their progress, so others may benefit from their discussions.
- **Publication strategies** can guide researchers toward a productive use of their work. For example, how should one publish negative evidence? Compile a list of journals that will accept GER articles.

4. Infusing Research Results into Educational Practices

Facilitator: Eric Riggs

Research and findings structure and content

- Triage the state of which research is "ready" for implementation, and which research is not "ready". Emphasize the most complete research when showcasing to the broader community.
- Research results need to be understandable for those outside the GER community. On one hand, GER results should be consistent with traditional research that faculty are familiar with. So the format, style, and data structure should be consistent with the whole field. On the other hand, GER results also need to be received by educators who do not come from a research background. In either case, research results should be written with the non-specialist in mind.

Encouraging implementation

- Show implementations in situ in someone's class, which may make it easier for others to adopt or adapt new approaches.
- Compile research results into synthesized and digested publications that will be more easily absorbed by non-researchers.
- Could be done by review papers, primers, or summary papers across styles of courses or areas of content
- These should be simple, short, accessible and interesting.
- Include digested research results in *In the Trenches.* Consider having a monthly column to report on GER activities, or have a guest columnist each month.
- Revive the NAGT Distinguished Speaker series with a GER focus so that GER experts can be brought to those who otherwise might not seek them out.
- Expand awareness to the broader scientific community that this research field exists and is valuable to their teaching.

Preparing the environment for implementation

- Ideally, adopting improved teaching practice will help an educator's career, but there is concern that trying out new teaching methods could (temporarily) result in lower student evaluations. Moreover, focusing time on curricular re-design can take time away from research or other duties. To ease these concerns, we can help work with departments and

faculty members to encourage people to implement new methods – without being penalized.
- Make sure the outreach from the GER community seeks to find out if faculty are willing to change, and to accept evidence of improved teaching as valid and valuable.
- Emphasize how effective teaching can improve faculty performance evaluations, which helps provide incentive and receptive environments.
- Help align stated learning goals and teaching plans and practice.
- Make sure learning goals are a valuable and measured outcome.
- Help map teaching approaches to demonstrated learning goals to illustrate how the teaching approach can be implemented.
- When writing summaries of the education research, provide the source of the original literature for those who want to do the deep dive.
- Promote revitalized teaching practice to early career and/or future faculty and/or willing faculty looking for a change.
- Many models exist in the K-12 world that could be adapted to grad/faculty professional development. For example, train the trainer.
- Provide certificates or competency-based badging for demonstrated competence, or graduate credit - onramp to adapt or lead to the CIRTL model perhaps? (CIRTL is the Center for the Integration of Research, Teaching, and Learning.)
- Faculty who specialize in teaching are wary of becoming "trapped" into becoming a service provider for their department. The GER community should share ideas for how to prevent this, and to compare notes to see how frequently this actually happens.

Instructional materials

- Become involved with the design of instructional materials so that they reflect the current state of the research, and to help make them engaging, appealing, and clear. This includes textbooks, web-based resources, etc.
- As lab activities or instructional materials come up for redesign, take that opportunity to include pedagogical content knowledge as part of the instructor's materials.
- Textbook publishers are starting to become part of the solution, but there is a ways to go in aligning their efforts with recommendations informed by GER research. We can continue to foster a collaborative relationship with publishers.

5. Building a Community Research Agenda

Facilitator: Tim Shipley

This group came at the day's questions from a different angle. Borrowing from approaches used in other disciplines (e.g., medical field), the group considered if and how a GER community research agenda could be developed. The goal would be to coordinate research efforts on a large scale to more efficiently compete for funding support on issues of greatest importance. This would require community buy-in for such an approach, and identification of critical problems, necessary resources, who is going to work on specific problems, and how to support critical research projects.

Therefore the GER community would need to answer:

- Is there a single GER goal (like curing a disease in the medical field) that the GER community can agree upon?
- Do we agree upon critical problems?
- Do we agree on resources?
- Can community provide "intellectual merit"?
- Can community provide "broader impacts"?

An example in the geoscience program could be a model: Within geoscience, the RIDGE program (interdisciplinary) did this to tackle the problem of understanding ocean ridges. The program offered workshops (white papers, which drove funding agenda), identified good field areas, had a coordinating office, worked to develop financial support, and brought together scientists from different fields who did not talk with other otherwise. Funded by 2@10years by NSF (dedicated pool- special RIDGE panels) so community decided by selecting appropriate reviewers. There was a shared goal and sense of excitement. It also had disadvantages in that some cliques arose around field areas.

What would a community research agenda in GER need?

- Far-seeing individuals (both inside and outside)
- A functional model. There are two options: a Center model (fund like InTeGrate, block of funds that then distributes to smaller groups (center model) or a Distributed Funding model, (ID proposer and community supports that person, use white paper for proposal text, and to point at as evidence for need in the community).
- A community-wide logic model
- Assessment instruments
- A path that leads to increased diversity
- Ways to allow new ideas to emerge
- Ways to ensure impact on society is clearly conveyed
- Ways to navigate changing political culture (

Possible goal

1) Geosciences solve a central problem, which is depletion of resources. Things follow from this like the need for systems thinking and understanding of feedback loops.

2) Workforce goal providing the training needed by employers of geoscience grads. Need to understand workforce and what is needed.

- These may be competing goals at k-12 technology needs pushes out earth science

3) Basic research question: how do geoscientists (from novice to expert) think and learn?

But why make them better? Why understand? ... Develop critical thinking? Avoid errors? Train to be critical thinker because the specific questions may change (climate, water, population growth)?

6. Metrics of Student Success

6a. What Are Metrics of Student Success for Geoscience Majors?

Facilitator: Karen Viskupic

Predicated on programs having outcomes that can be measured.

Recognition that programs that produce geoscience majors are diverse in their disciplinary focus.

What are we currently using as metrics for geoscience major student success?

- University-designed surveys that are provided to the department
- For each outcome defined by the department, each class identifies which outcomes are met in that class and an assessment in that class must relate to each program-level outcome. There's a rubric associated with evaluating these assessments.
- Set questions used as pre-post test; some multiple choice, some short answer, test developed by faculty in the department (biology in this case)
- In an intro course, there's a certain set of questions on the exam that students will see again in subsequent courses. These questions are not given back to students.
- Job placement of graduates and graduate school acceptance of graduates
- Use EOS 2009, Kastens, et al. article about how geoscientists think and learn–all students read this, and department uses this framework to put a disciplinary spin on assessment of higher level skills–thinking spatially, temporally, etc.
- Students take our courses and get grades in those courses
- Student performance in "capstone" type experiences
    - Capstone research projects
    - Internships
    - Capstone field course
- Alumni surveys
- Three courses taken during final year that map to the three learning outcomes of the program; guided by accreditation process for school (may be different for other schools at the university).

What do we wish we had?

- Community-wide assessments that map onto the skills associated with being a geoscientist, but based in the content of the discipline
- A way to customize such an assessment for your own program based on the disciplinary-emphasis of your program

- A single spatial assessment that assesses multiple dimensions of spatial thinking that are relevant to geosciences. Ideally this assessment would be validated and there would be a national comparison data set. The same thing is needed for temporal thinking.
- Need database of national assessment data for comparisons.
- We need a better way of tracking people through your program and after they leave
- We'd like to know more about what employers want and expect from our students.

Other discussion items:

- Do institutional research offices at universities collect information on student skills (i.e. communication, collaboration, self-efficacy, etc.)?
- Do we want to look at the students as they exit our program, or do we want to look at them 10 years out? Many of them will not have jobs as geoscientists, so what are the general skills that serve students well regardless of their career path?
- The definition of geoscience is very broad, so we need broad measures. Hard to define a standard set of measures.
- Hard to track students after they leave the university (they lose their university e-mail address, etc.)
- How do we scaffold learning throughout a program? Do we do this well?

6b. Metrics of Student Success in Geoscience General Education Courses

Facilitator not listed

What is the purpose of geoscience general education classes?

- Can help form a pool for potential majors
- Help to inform citizens and voters
- Serve as introductory class for majors

Broad student types have different motivation and prior skill sets:

- Interested in subject; may or may not become a major
- Simply want to fulfill requirement
- Taking this course as a requirement for other majors

What happens in general education courses?

- Identifying fears and misconceptions about science, for example, dealing with uncertainty
- Students become more informed citizens about environmental issues
- Geoscience lab classes aren't same as other disciplines – we don't always get at experimental design
- Learning content and geoscience language

- Evaluate good sources of information
- Guiding students for modern topics
- Seeing what scientists do?
- Can we find "accessible" research articles to share with the community to help teach?
- View their world differently through geoscience lens
- Make connections to their lives that they are not aware of
- Addressing misconceptions about intro geoscience classes - how do we dispel any negative reputation (e.g., rocks for jocks – perhaps popular, but not taken seriously)?
- Science literacy - key
- Raising awareness of misinformation
- Geoscience is a vehicle for science literacy
- Goals - collect and analyze data; tectonics; systems thinking, writing, oral presentation, evidence (recognize, use, graph use); understand science and how it works, what scientists do, interested in science and earth, more informed citizens; geoscience goals