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Julie R. Posselt

Jason A. Chen


Grady Dixon

Jerlando F. L. Jackson

Robert Kirsch

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Authors

Julie R. Posselt, Jason A. Chen, Grady Dixon, Jerlando F. L. Jackson, Robert Kirsch, Anne-Marie Nuñez,
and Brian J. Teppen

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Authors

Dr. Julie R. Posselt, Associate Professor, University of Southern California, Rossier School of Education, 3470 Trousdale Parkway, 602g WPH, Los Angeles, CA 90089, Phone: 213-740-6865; Email: posselt@usc.edu

Dr. Jason Chen, Gerdelman Family Term Distinguished Associate Professor of Education, College of William & Mary, School of Education, 301 Monticello Ave., Williamsburg, VA 23185. Phone: 757-221-6201. Email: jachen@email.wm.edu

Dr. Grady Dixon, Professor and Chair, Department of Geosciences, Fort Hays State University, 600 Park St, Hays, KS 67601, Phone: 785-628-4536; Email: pgdixon@fhsu.edu

Dr. Jerlando F. L. Jackson, Vilas Distinguished Professor of Higher Education, Department Chair of Educational Leadership and Policy Analysis, School of Education, University of Wisconsin-Madison; 575 Educational Sciences; 1025 W. Johnson Street; Madison, WI 53706. Email: jjackson@education.wisc.edu

Dr. Robert Kirsch, Assistant Professor, Arizona State University, College of Integrative Sciences and Arts, 651 E University Dr., Tempe, AZ 85287, Phone: 480-727-3262
Email: rekirsch@asu.edu

Dr. Anne-Marie Nuñez, Professor, The Ohio State University, College of Education and Human Ecology, 29 W. Woodruff Avenue, Columbus, OH 43202. Email: nunez.80@osu.edu

Dr. Brian J. Teppen, Professor, Michigan State University, College of Agriculture and Natural Resources, 1066 Bogue Street, Room 283, East Lansing, MI 48824, Phone: 517-528-3370; Email: teppen@msu.edu

Abstract

Here we report on five pilot projects working to develop effective professional development aimed at improving diversity, equity, and/or inclusion within the geosciences. All five projects were funded by the NSF GEO Opportunities for Leadership in Diversity (GOLD) program, which was designed to bring together geoscientists and social scientists to create innovative pilot programs for preparing and empowering geoscientists as change agents for increasing diversity. Each project has different objectives and applies different combinations of methods, but focus on professional development, bystander intervention training, and the formation of new networks in the pursuit of systemic, institutional change. This paper describes the origins, aims, and activities of these projects, and reflects on lessons learned to date. These projects are still ongoing, but in their first two years have received more interest than anticipated and more demand than can be fulfilled, suggesting an unserved need in the field. We have also found that teams with varied backgrounds, experiences, and expertise are vital to overcoming common struggles in facing inequalities. Coaching from experts in diversity, equity, and inclusion keeps the teams motivated, particularly when many team members are accustomed to typical scientific research. Finally,

40 institutional change requires time to catalyze, develop, and institutionalize, highlighting the
41 importance of sustained effort over years.

42

43 **Keywords:** Geosciences, Equity, Diversity, Inclusion, Leadership, Ideas Lab

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Introduction

47 The share of women earning geoscience degrees has reached 40 percent (Wilson, 2018),
48 representing a significant increase over the past four decades (Bernard & Cooperdock, 2018), but
49 the discipline still lags behind STEM fields as a whole (NSF, 2017). Over the past 40 years,
50 about 85% of US Citizen PhD recipients in the geosciences have come from White, non-
51 Hispanic backgrounds, whereas 7% have come from racially/ethnically underrepresented groups
52 (i.e., African American, Hispanic/Latinx, and Native American) (Bernard & Cooperdock, 2018).

53 The remainder are mostly Asian-Americans, and a smaller number who do not identify with a
54 single race/ethnicity. The share of underrepresented students earning bachelor's degrees in the
55 geosciences in 2017 was 8% (Wilson, 2018). Over the past 40 years, the proportion of
56 underrepresented groups earning degrees in the discipline has not changed (Bernard &
57 Cooperdock, 2018).

58 Recognizing the need for systemic change to disrupt these trends and encourage
59 diversity, equity, and inclusion, NSF-GOLD was established. The name "GOLD" (GEO
60 Opportunities for Leadership in Diversity) is derived from the Directorate for Geosciences
61 (GEO) and the desire to identify and enhance discipline-specific leaders who can make positive
62 changes in the area of diversity. More specifically, the purpose of GOLD is to prepare and
63 empower scientists to become agents of change for increasing diversity. GOLD Program leaders
64 at NSF employed a novel method, called an "Ideas Lab", for achieving these goals.

65 **Origins in the Ideas Lab Format**

66 The NSF Ideas Lab is a method to encourage novel questions and ideas from a diverse
67 group of participants. Participants meet for 5 full days of intense activities designed to challenge,
68 frustrate, stir emotions, and force collaboration. There is little or no agenda shared with
69 participants in advance, and the result is a series of research or other project proposals. The
70 concept was originally created in the U.K. in 2003, where they are called “Sandpits,” and NSF
71 has been using Ideas Labs since 2009.

72 For the GOLD Ideas Lab, NSF invited a diverse group of 30 participants—geoscientists,
73 social scientists, and other practitioners working in STEM. Led by Knowinnovation, a company
74 that commonly facilitates Ideas Labs and Sandpits (<https://knowinnovation.com>), the end goal
75 for all this creative energy was for these 30 individuals to design and develop collaborative
76 professional development programs that could be field tested with small groups of geoscientists,
77 with the goal of using these pilot projects as a proof-of-concept to scale up. NSF, in consultation
78 with Knowinnovation, selected geoscientists as well as those with expertise in behavioral
79 change, social psychology, leadership development, and other related areas. NSF also brought in
80 a director and five “mentors” who had histories of working in the areas of diversity, equity, and
81 inclusion in science. Although the mentors participated fully in the Ideas Lab, they were not
82 eligible for funding because they were also acting as impartial reviewers of the participants
83 working toward proposals.

84 Every day of the Ideas Lab was densely scheduled with breaks for little more than three
85 meals from 8:00 a.m. until 8:00 p.m., and most participants continuing to work together until
86 around midnight each day. This process resulted in several great ideas. Many participants had at
87 least some role in multiple ideas, and not all great ideas were fully developed. Nevertheless, by
88 the end of the week, participants pitched the most feasible and most popular six proposals were

89 to a panel of NSF program officers. Based on these presentations, NSF invited the most
90 promising projects to submit full proposals to NSF. Five proposals were eventually funded.

91 **GOLD Projects**

92 The author team of this commentary includes at least one PI from each of the projects that are
93 funded by NSF GOLD. The projects each seek to build leadership capacity of individual
94 scientists and the organizations in which they work. Collectively, the projects capture the
95 multiple contexts in which geoscience education occurs, and aim to:

- 96 · Cultivate an ethical model of community-based geoscience research,
- 97 · Create more equitable cultures of geoscience fieldwork,
- 98 · Leverage the influence and wisdom of senior scholars toward inclusion,
- 99 · Empower faculty to recognize and respond to prejudice in workplaces,
- 100 · Change departmental culture by supporting small groups of change agents

101 In what was an initially discomfoting aspect of the initiative, NSF representatives pushed the
102 PIs to orient projects toward engaging with parties other than students—namely, toward people
103 with power to make decisions that affect student participation. This conceptual orientation is
104 consistent with evidence that organizational change can happen by changing the mindsets and
105 practices of gatekeepers and other leaders (Bensimon, 2005; Kezar, 2012; Posselt, 2016).

106 In this respect, the inclusion of both geoscientists (about 75%) *and* social scientists (about
107 25%) on project teams has been a defining feature of GOLD. It enables a crucial strategy across
108 these diverse projects: equipping geoscientists, who are not trained in social science, with current
109 theories for: (1) discussing diversity, equity, and inclusion; (2) implementing effective
110 educational practices; and (3) effecting changes toward these goals. Well-intentioned
111 geoscientists may know, for example, the importance of saying something when they see

112 harassment or assault, but rarely do they know quite how to handle such situations when they
113 arise. Training in bystander intervention in three of the five GOLD projects has begun to
114 empower scientists with knowledge and skills to make their work more inclusive.

115 **Summaries of Projects, Research, & Theories**

116 In addition to their shared origins in the Ideas Lab process and multidisciplinary
117 leadership teams, the initial GOLD projects have conceptual and programmatic similarities,
118 which are summarized in Table 1. All five include professional development opportunities for
119 participants, and are oriented toward the broad aim of changing institutional culture. Three of the
120 five create new social or professional networks, all five explicitly address equity, diversity, and
121 inclusion as systemic issues, and three offer bystander intervention training as part of
122 professional development.

123

124 **Table 1. Features of NSF-GOLD Pilot Projects**

Project	Professional Development Included	Bystander Intervention Training	Explicitly Addresses Systemic Issues	Forms New Social or Professional Networks	Changes Institutional Culture
ASPIRE	Y	Y	Y	N	Y
Novelty: Community-engaged science broadens vision of what and whom science is for; Social science research design contributes to reflection and growth by mobile working group leaders					
FIELD	Y	Y	Y	Y	Y
Novelty: Focus on field work; Participants were leaders of field experiences at a variety of institutions, representing a full range of career stages.					
GeoDES	Y	Y	Y	N	Y
Novelty: Mixed-reality simulations to help geoscience faculty identify prejudices and prejudicial structures, and then take action to redress those issues.					
Hearts of Gold	Y	N	Y	Y	Y
Novelty: Multiple cohorts of senior scientists learning how to use their influence to spread allophilia (i.e., love of those who are different) in support of healthier cultures for diverse students and colleagues					
Sparks for Change	Y	N	Y	Y	Y
Novelty: Mentoring triads of early-career faculty from an underrepresented group, senior faculty, and external expert on broadening participation					

125

126 **ASPIRE (Active Societal Participation in Research and Education)**

127 A common paradigm for science is discovery emanating from curiosity about the natural
128 world, carried out by testing discipline-specific theory. Disenfranchised communities, however,
129 may see problems emanating from environmental injustices as more relevant than theory-
130 generating research as relevant; therefore, a growing number of scientists are moving out of the
131 ivory tower, and directly into communities to conduct geoscience research that addresses
132 community-identified problems that are both social and scientific. ASPIRE pilots a model of
133 place- and community-based geoscience research distinguished by scientists and community
134 members, facilitated by an individual who has a foot in both worlds. Together, they collaborate
135 in an ethical exchange of knowledge, values, and cultural perspectives about one specific

136 ecological, environmental, or geoscience challenge. ASPIRE supports six mobile working
137 groups of scientists and community members addressing local challenges using the tools of
138 geoscience. Presently, three groups are supported for research in South Dakota, Hawaii, and Los
139 Angeles, with three more to start up in 2019. One project, led by Dr. Andres Aguilar of
140 California State University- Los Angeles, engages community members who live, work, and
141 play along the Los Angeles River to measure the chemical composition of river water and its
142 safety for various purposes. Their measurements are informing Aguilar's scholarship and
143 clarifying appropriate uses of the river water. Another study brings together a family-owned
144 watercress farm just outside of Honolulu with researchers from the University of Hawaii-Manoa
145 to understand how urbanization and changing water policy are affecting the water quality on
146 their farm and, by extension, the crops and the indigenous farm's sustainability.

147 How projects and others, in practice, resemble the idealized model of ethical place-based
148 research is one topic of research underway. Another research aim is advancing knowledge of
149 what leadership of place-based, community-based science entails. ASPIRE uses cultural
150 sociological theories about social and symbolic boundaries to understand how working group
151 leaders operate as boundary spanners, linking the cultures and approaches to knowledge
152 production among communities and geoscientists. Mobile working groups of principal
153 investigators are participating in a narrative inquiry over the course of their project-- including
154 extended pre-post interviews as well as writing monthly logs on issues of common concern. The
155 research model ASPIRE pilots strives to integrate both scientists' sensibilities and those of
156 communities who have been excluded or opted out of the geosciences.

157 **FIELD (Fieldwork Inspiring Expanded Leadership for Diversity)**

158 Fieldwork is a central activity for geoscience learning, and has been characterized as “a
159 key benchmark in the transition from student to scientist and from novice to expert” (Feig, 2010,
160 p. 249). However, cultural dynamics like financial cost, anxiety about outdoor experiences,
161 attitudes of ableism, and threat of sexual assault also prevent some people from entering or
162 continuing in the discipline. The association of geosciences with outdoor activity can hinder the
163 engagement of some populations, including those from black, Latinx, and indigenous
164 backgrounds (e.g., O’Connell & Holmes, 2011; Stokes, Levine, & Flessa, 2015). For these
165 populations, the wilderness can be associated with human histories of natural resource extraction,
166 military expansion, labor exploitation, colonization by settlers, and dispossession of land, each of
167 which has been facilitated in some part by disciplinary practices of geosciences (e.g., Whyte,
168 2017; Yusoff, 2018). For example, in the U.S., slavery and Jim Crow laws made the rural
169 outdoors dangerous for African Americans, especially in the South (e.g., Edmondson, 2006;
170 Finney, 2014; Hackmann, 2015); concern about safety in rural areas remains a legacy of this
171 history for some African American college students today. Globally, the mining of natural
172 resources, such as gold, coal, and tin, has been associated with exploitative labor with Asian,
173 Black, and Indigenous peoples (Whyte, 2017; Yusoff, 2018). FIELD aims to raise awareness of
174 historical, engrained barriers in geoscience field experiences and to make field activities more
175 inclusive by equipping leaders with perspective, skills, and solidarity.

176 The initial phase of the project involved ethnographic research by social scientists (i.e.,
177 authors Nuñez and Posselt) in an undergraduate field camp and graduate-level field course.
178 Findings highlighted how typical classroom or lab boundaries break down in the field, with
179 positive and negative consequences for inclusivity. Fieldwork demands of generating hypotheses
180 about the formation of landscapes inspired cognitive, social, and physical disequilibria that can

181 inspire unique learning (also see Feig, 2010; Mogk & Goodwin, 2012), but also requires
182 instructors to attend all students' wellbeing and engagement. Working long hours in high
183 temperatures, for example, put students in one of the courses at risk for heat stroke.

184 Next, the FIELD project convened a three-day leadership institute for faculty and field-
185 camp geoscientists. Drawing on the research of the project's first phase, the FIELD Institute at
186 Colorado State University's Mountain Campus offered training in practical skills like bystander
187 intervention, managing cross-cultural relationships, and more. It also facilitated opportunities for
188 collaborative development of new approaches to fieldwork. The final phase will consist of
189 evaluation, assessment, and construction of a professional leadership model based on results of
190 the FIELD Institute. FIELD Institute participants will work together to interrupt and advance
191 new alternatives to these dynamics in their own sites, and the leadership team intends to generate
192 models for inclusive fieldwork that can be adapted across all educational levels.

193 **GeoDES (Geoscience Diversity Experiential Simulations)**

194 GeoDES aims to provide professional development for a cohort of 30 geoscientists to
195 develop their (1) knowledge of social justice issues in geosciences; (2) bystander intervention
196 skills; and (3) leadership skills for targeting exclusionary gatekeeping decisions. Critical
197 elements of the approach included an intensive three-day workshop and three mixed-reality
198 simulations, which combine human conversational intuition with artificial intelligence. The
199 "human-in-the-loop" architecture used in GeoDES simulations provide highly authentic and
200 realistic scenarios that allow project participants to learn and practice specific skills and
201 strategies that they learn throughout the project. For example, one simulation provided
202 participants with the opportunity to learn and practice how to recognize biases that arise in
203 faculty search committees and then to advocate for promising candidates who do not possess

204 such traditionally valued experiences as graduating from a prestigious elite university, publishing
205 in a journal that the committee members recognize, and having a well-known mentor. On-going
206 professional development also included monthly virtual meetings in which participants discussed
207 applying their knowledge and skills to their home institutions.

208 To date, the GeoDES team has collected longitudinal survey data at four time points
209 spanning one year of participation. We (i.e., authors Chen, Jackson, and Teppen and the
210 GeoDES leadership team) have also collected audio and video data of our participants engaging
211 in the mixed-reality simulations. Although we are in the beginning stages of data analysis, we
212 have some preliminary findings from the quantitative data. Using a Bayesian analytical
213 approach, we found that participants' ($n=29$) beliefs about their individual capabilities (i.e., self-
214 efficacy) and beliefs about their department's collective capabilities (i.e., collective efficacy) to
215 confront prejudices and prejudicial structures grew sharply from the start of the project
216 [Mean(self-efficacy)=3.45; Mean(collective efficacy)=3.14] to three months after starting
217 [Mean(self-efficacy)=4.38; Mean(collective efficacy)=3.96]. Although self-efficacy had declined
218 to a mean of 3.78 and collective efficacy to 3.28 one year later, there was still overall growth
219 from start to end. To put more fine-grained details to this overall landscape of self-reported
220 changes in beliefs, we plan to use the video data of participants in the three simulations to
221 explore the variety of ways that participants approached the situations presented to them in the
222 simulations and the degree to which they challenged prevailing norms tactfully.

223 Ideally, GeoDES participants develop multiple habits for leading organizational-level
224 change by: a) intervening whenever exclusionary behavior is witnessed, b) strategically
225 advocating for marginalized voices when participating in key gatekeeping decisions such as
226 hiring, and c) changing institutional policies such as annual merit review processes to reward

227 people who engage in diversity, equity, and inclusion efforts. Participants learn a social closure
228 model (Murphy, 1988) that helps articulate the processes by which exclusion occurs. Further,
229 GeoDES participants engaged in mixed-reality simulations in which they *practiced* all three of
230 these forms of leading change. Research can inform the scaling up of this type of innovation to
231 larger groups, thereby generating broader impacts on other fields.

232 **Hearts of GOLD**

233 Hearts of GOLD aims to develop and test professional development training for
234 established scientific leaders in the geosciences — the GOLD Institute — to give them the
235 content knowledge, tools, and skills needed to become champions of change for diversity. It is
236 hosted in Colorado Springs and facilitated by Drs. Dena Samuels and Stephany Rose of the
237 Knapsack Institute at the University of Colorado- Colorado Springs.

238 Its task is to move attitudes among opinion leaders in the geosciences away from negative
239 intergroup attitudes to positive ones. Pittinsky (2005) describes those positive intergroup
240 attitudes as “allophilia,” borrowed from the Greek for “love of the other.” We need to foster
241 those positive attitudes among opinion leaders, because they can promote behavior change
242 among those around them (Valente and Pumpuang, 2007). Its method is inspired by Wenger's
243 Communities of Practice (Wenger, 2000) where leaders set the values for the community but
244 often have little access to other communities to bring in new ideas. The GOLD Institute provides
245 this access by hosting two cohorts that receive a two-day, transformative, intensive workshop
246 targeted at existing scientific leaders to develop them as leaders in diversity. These leaders will
247 promote scalable change by taking action to promote allophilia within their home institutions and
248 within their roles as members of professional societies. Furthermore, participants will form a

249 national network of geoscientists who support each other in extending allophilia throughout the
250 geosciences.

251 Hearts of GOLD employs the most conservative strategy of the GOLD projects, but has a
252 multi-cohort model that will help promote grassroots growth over time. Accordingly, five
253 participants from the first cohort joined those in the second to help bridge the two groups.

254 **Sparks for Change**

255 The Sparks for Change team uses a model of small group dynamics so early-career,
256 underrepresented minority faculty can become effective leaders in changing department culture
257 concerning diversity, equity, and inclusion in the geosciences. These groups consist of an early-
258 career, underrepresented minority faculty member, and senior faculty member from the same
259 unit, as well as an expert on broadening participation who is external to that unit. Each member
260 of the small group emphasizes a specific leadership style relevant to their position in the
261 department. The project held a three-day workshop in 2017 to highlight these leadership styles,
262 build social bonds within and among small groups for post-workshop support, and develop
263 action plans that utilize leadership insights to change department culture toward diversity, equity,
264 and inclusion.

265 Research begins with identifying an institutional inertia in geoscience departments.
266 Although many departments are in principle open to diversity, equity, and inclusion, there may
267 nevertheless be benefits to maintaining the status quo. Overcoming the diffuse benefits of the
268 status quo requires group of active, empowered change agents. The project hypothesizes that
269 small groups of committed change agents will change the department culture with a concrete
270 action plan in order to overcome that inertia (Bergstrom, 2010). This is an emergent approach to
271 changing department culture specific to the institution where change agents are located and does

272 not focus on top-down directives; rather, leadership development unlocks the skills and
273 capacities that small group members already possess and asks them to leverage those skills to
274 effect change.

275 A promising possibility from the Sparks model is its potential for proliferation. It is
276 lightweight and scalable, and shows how accomplishing small goals might be scaled up to
277 broader contexts (McGinnis & Ostrom, 2007). Another aspect of this research is the role of the
278 outside expert, who may keep the group focused on breaking inertia and enabling broader
279 change.

280 **Reflections and Recommendations**

281 Though data collection and the required external project evaluation are still underway in
282 a majority of the projects, we have learned that project similarities are more than a function of
283 the common funding stream and our shared focus on building capacity for diversity leadership.
284 Several noteworthy patterns have emerged. First, although our small pilot projects were funded
285 to accept only 30 participants, our projects received far more requests to participate than we were
286 able to accept. In fact, some participants even volunteered to pay their own way to attend
287 institutes and trainings associated with the projects—clear indications of hunger within the
288 geosciences to learn how to facilitate change and enact values of diversity, equity, and inclusion.
289 Upon attendance, participants have eagerly engaged with the opportunities for professional
290 development that these projects offer, which include network formation, self-reflection, dialogue,
291 and bystander intervention training. Simply learning to notice and label bias can lead to more
292 inclusive attitudes and (perhaps) actions (Forscher et al., 2017). Equipping scientists with social
293 knowledge and skills appears to be an important, underrecognized lever for change.

294 As the projects mature, we will also be attending to barriers to sustainable change within
295 scientific and educational institutions, such as those related to the existing academic incentive
296 structures. For example, in FIELD, leaders may be committed to more inclusive practices, but
297 these may increase financial costs in a time that funding for fieldwork is already threatened or
298 declining. We will have more to report on barriers by the end of the pilot phase, but anticipate
299 now that clarity about these barriers will only reinforce GOLD's focus on systemic change.

300 For other geoscience educators engaged in diversity, equity, and inclusion efforts, we can
301 make a few early recommendations: First, geoscience education is inherently interdisciplinary,
302 and the problems of exclusion and lack of diversity are inherently social. We thus endorse
303 GOLD's vision of leadership teams representing diverse social identities and both social and
304 hard sciences, who bring distinctive knowledges and ways of knowing to the work. Social
305 scientists have brought in new research tools and practices, enhanced the awareness and
306 intentionality of research design, and allowed for more rigorous evaluation. Geoscientists on
307 each project ensure alignment of efforts with geoscience cultures and translate social science
308 concepts to participants. PIs, participants, and coaches alike are becoming geo-social-science
309 boundary spanners. For example, all of the authors of this manuscript continue working closely
310 across disciplines, supporting and learning from each other.

311 Second, diversity does not come without its challenges--differing disciplinary cultural
312 norms and social identities may yield misunderstandings within even high-functioning teams.
313 We therefore recommend leadership teams include external advisors or coaches. For example,
314 during the Ideas Lab, even though participants were a diverse group with diverse expertise, NSF
315 was intentional about hiring an external group to facilitate the creative idea-generation while
316 keeping participants within the boundaries of what the program would realistically fund.

317 Furthermore, as the projects started and matured, NSF funded two coaches, Diana Kardia and
318 Kelly Mack, to help manage potential conflicts among and within GOLD groups so that our
319 diversity could be transformed into products such as a podcast series that explores the skills and
320 experiences required to lead efforts to broaden participation. Please see Kardia Group, LLC
321 (2018).

322 Finally, work like this takes time. Therefore, we recommend project development on the
323 time scale of at least three to five years, particularly if leaders have not previously worked
324 together. In our own experience, with more participants, a longer timeline, more substantial
325 funding, and more cross-fertilization among the projects, our potential for impact would no
326 doubt be greater.

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Endnotes

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[1] We use women/men for NSF gender identity statistics, reserving the language of female/male for instances where biological distinctions are relevant to the discussion at hand.

[2] For details and history of the Ideas Lab format within NSF, please see https://nsf.gov/discoveries/disc_summ.jsp?cntn_id=136669. For details of the original solicitation by NSF-GEO, please see <https://www.nsf.gov/pubs/2016/nsf16516/nsf16516.htm>