

Earth's Future

RESEARCH ARTICLE

10.1029/2020EF001624

Key Points:

- From a sample of $n = 281$, we examine how engineers/scientists view incentives, barriers, and potential for community-based collaborations
- We find relations of race, class, and experience that suggests that sociodemographic conditioning informs community-based collaborations
- Four barriers to community collaborations are identified: lack of time, lack of funding, lack of rapport, and knowledge deficits

Supporting Information:

- Supporting Information S1

Correspondence to:

J. L. Boucher,
jean.boucher@asu.edu

Citation:

Boucher, J. L., Levenda, A. M., Morales-Guerrero, J., Macias, M. M., & Karwat, D. M. A. (2020). Establishing a field of collaboration for engineers, scientists, and community groups: Incentives, barriers, and potential. *Earth's Future*, 8, e2020EF001624. <https://doi.org/10.1029/2020EF001624>

Received 19 MAY 2020

Accepted 20 SEP 2020

Accepted article online 25 SEP 2020

Author Contributions:

Conceptualization: J. L. Boucher, A. M. Levenda, D. M. A. Karwat

Data curation: J. L. Boucher, A. M. Levenda

Formal analysis: J. L. Boucher, J. Morales-Guerrero

Funding acquisition: D. M. A. Karwat

Investigation: J. L. Boucher, A. M. Levenda

Methodology: J. L. Boucher, A. M. Levenda, M. M. Macias, D. M. A. Karwat

Project administration: D. M. A. Karwat

(continued)

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Establishing a Field of Collaboration for Engineers, Scientists, and Community Groups: Incentives, Barriers, and Potential

J. L. Boucher¹ , A. M. Levenda² , J. Morales-Guerrero³, M. M. Macias⁴, and D. M. A. Karwat^{1,5} 

¹School for the Future of Innovation in Society, Arizona State University, Tempe, AZ, USA, ²Department of Geography and Environmental Sustainability, University of Oklahoma, Norman, OK, USA, ³School of Sustainability, Arizona State University, Tempe, AZ, USA, ⁴Ira A. Fulton Schools of Engineering, Arizona State University, Tempe, AZ, USA, ⁵The Polytechnic School, Arizona State University, Mesa, AZ, USA

Abstract With the aim of mobilizing engineers and scientists to address environmental, climate, and energy justice challenges in the United States, this study examines how engineers and scientists view their incentives, barriers, and potential for community-based collaborations. Through a purposive convenience sample ($n = 281$) and an online questionnaire, we investigate the attitudes and experiences of engineers and scientists regarding their community-based work. Our analyses reveal dynamics of race, class, and experience, suggesting a type of socio-demographic conditioning informing community-based collaborations. Engineers and scientists also identify four main barriers to community-based work: lack of time, lack of funding, lack of rapport, and knowledge deficits. In response, we introduce a field of collaboration with its own set of capitals—economic, cultural, social, and symbolic—and offer recommendations on how engineers, scientists, and community groups might collaborate with each other to address longstanding issues of energy, climate, and environmental injustice in the United States.

1. Introduction

It is not difficult to argue that there is a great need for engineers and scientists to engage with those who lack access to technical resources—scientific tools, knowledge, and skills, particularly in communities struggling for environmental justice (Ottinger, 2013; Ottinger & Cohen, 2011). There have been, in turn, numerous calls for those with expertise to acknowledge and address said technical challenges in communities (Bielefeldt, 2018; Lubchenco, 1998). Pandya (2014) suggests “closing the gap” between science and society and describes how those who participate in defining scientific questions will dictate “whether science results are pushed out from scientists or pulled into community priorities” (2014, p. 56).

In seeming response to these technical gaps, professional societies and advocacy organizations have created programs to engage engineers and scientists in community-based work. For example, the American Geophysical Union (AGU)'s Thriving Earth Exchange has connected engineers and scientists to over a hundred projects that address issues from greenhouse gas emission inventories to hydrology (AGU, 2020). The American Association for the Advancement of Science program called On-Call Scientists has also connected hundreds of engineers and scientists and human rights organizations in the United States and abroad (AAAS [American Association for the Advancement of Science], 2020). Engineers Without Borders recently started Community Engineering Corps, which leverages a network of more than 200,000 professional engineers, to address water, energy, civil, and structural engineering challenges for communities that generally cannot afford professional engineering services (CEC [Community Engineering Corps], 2019).

Through this study, we desire to contribute to an increased involvement of engineers and scientists with community-based work, and thus, we explore how technical experts can be better supported in addressing environmental, climate, and energy justice issues. One can imagine analogies to the field of public interest law, which has fundamentally transformed legal practice (Cummings, 2007; Freedman Consulting, 2016). Might a similar practice be created for engineers and scientists? Prompted by this interest, we seek to identify and examine the incentives, barriers, and potential for engineers and scientists to engage their insights, skills, and resources with community-based groups. In what follows, we (1) appraise the pertinent

Resources: J. L. Boucher, D. M. A. Karwat

Software: J. L. Boucher

Supervision: J. L. Boucher, D. M. A. Karwat

Validation: J. L. Boucher

Visualization: J. L. Boucher

Writing - original draft: J. L. Boucher, A. M. Levenda, D. M. A. Karwat

Writing - review & editing: J. L. Boucher, A. M. Levenda, D. M. A. Karwat

literature of engineering, science and technology studies, some sociology, and education; (2) review our methods and data, both quantitative and qualitative; (3) present our findings on the incentives, barriers, and potential for community-based efforts; and (4) discuss our findings and offer recommendations for developing a *field of collaboration* between engineers, scientists, and community groups.

2. Review of the Literature

Efforts to broaden the purview of engineers and scientists to include more social and environmental issues are not new (Hively, 1988; Strauss, 1988), and these efforts have come in different forms and from different sources. (In this section, the terms *engineers* and *scientists* are sometimes used synonymously as comparable representatives of a STEM discipline.) Professional organizations have been vocal, from the 1960s origins of the Union of Concerned Scientists (Hively, 1988) to other national-level associations and foundations (National Academy of Engineering [NAE], 2008; National Science Foundation [NSF], 1989). The fundamental argument has been that the STEM fields—disengaged from the real needs of people—have neglected their social and environmental commitments (Beder, 1998; Strauss, 1988). In other words, they are disengaged from social and political issues (Cech, 2013). Seemingly speculating on reasons for disengagement, Mills (1956, p. 353) refers to the “man of knowledge... as an “expert” which usually means a hired technician... [and like] most others in this society, [is]... dependent for his livelihood upon the job, which nowadays is a prime sanction of thought control. Where getting ahead requires the good opinion of more powerful others, their judgements become prime objects of concern. Accordingly, in so far as intellectuals serve power directly—in a job hierarchy—they often do so unfreely.”

As a result, scholars have offered innovative labels to initiate a transformation in these fields, like the “new engineer,” who is more broadly trained in social and environmental issues (Beder, 1998; Conlon, 2008; Green, 2001), or the “humanitarian engineer,” who is educated to work on international development projects (Conkol, 2012; Vandersteen et al., 2009, 2010), or, more recently, the “activist engineer” who asks, “What is the real problem and does this problem ‘require’ an engineering intervention?” (Karwat, 2019, p. 227; Karwat et al., 2015). There is also writing on *engineering justice* (Leydens & Lucena, 2017). There is, in turn, speculation on how to change engineering education for this new generation of engineers that will build “a more sustainable, stable, and equitable world” (Amadei and Sandekian, 2010, p. 84). Thus, researchers and academics have developed educational frameworks like *sustainability engineering* (Abraham, 2006) and *green engineering* (Hesketh et al., 2006). Though efforts where students are taught to engage broader purposes and greater socio-environmental visions are laudable, these programs can still be overwhelmingly technical in curricular content. Consequently, scholars also argue for a dose of socially-minded skills, like training in ethics, the dynamics of power and privilege, cultural awareness/sensitivity, and listening skills (Cech, 2013; CSD [Center for Science and Democracy], 2016; Kinsner, 2014; Lambrinidou et al., 2014; Larsen et al., 2014; Skokan & Munoz, 2006; Vandersteen et al., 2009). For Vandersteen et al. (2009, p. 33), the success of one’s placement in an international type program “often depends on intangible qualities, such as the student’s attitude, communication skills, and cultural awareness.” For greater detail on such skills, see the *Center for Science and Democracy’s* guide to scientist-community partnerships (CSD, 2016).

One barrier to address will be the engineer/scientist stereotype: the socially awkward nerd with a narrow set of technical interests and a passivity or even an active distancing over broader sociopolitical issues (Beder, 1999; Cech, 2013; Florman, 1997; Karwat, 2019; Karwat et al., 2015; Riley, 2008). There is also a professionalizing culture to overcome and the commitment required by engineers and scientists to their employers—often a corporation—that seek normative control over their hearts and minds (Kunda, 2009; C. W. Mills, 1956). Some scholars argue that an education in engineering itself is complicit in disengaging students from social responsibilities (Canney & Bielefeldt, 2015; Cech, 2014). Moreover, when approaching underserved populations, engineers and scientists may encounter a skepticism held toward them as representatives of powerful institutions (Horowitz et al., 2009), a skepticism that comes from a long history of experts and researchers conducting work in ways that marginalize community groups, like not including their voices in defining issues and creating solutions (Ottinger & Cohen, 2011; Ottinger & Cohen, 2012), and poor follow-up on implementations (Brown et al., 2019). There is also evidence that engineers and scientists do not have adequate time, funding, or the essential institutional support for engaged community-based work (Beaulieu et al., 2018), and it can negatively impact one’s professional standing, especially if perceived

as advocating for a social or political agenda (CSD, 2016). This challenge exists despite evidence that endeavors in engineering and science are inherently political (Hecht, 1998; MacKenzie, 1993; Ottinger, 2013).

2.1. Assessing New Conceptions of Engineering: Education and Beyond

Studies to evaluate efforts to create a new type of engineer, its progress and impacts, often focus on engineering education, curricula, and students (Canney & Bielefeldt, 2015; Carew & Mitchell, 2002; Skokan & Munoz, 2006). (Though students are more available for study, they should not be considered representative of any field as a whole.) There are two fundamental challenges with such studies: self-selection bias (Litchfield et al., 2016)—those who are already socio-environmentally minded before the study—and the longevity issue. With respect to longevity, a student may have a powerful service learning experience, but the impact may not last long, especially after one enters the job market, and studies do not measure this longevity dynamic. Florman (1997) frames the issue well by identifying a “Catch-22” between the cultural training of a broad-minded student versus its potential degeneration in a narrow-minded profession where status is defined by technical savvy.

However, some studies find that service learning has positive effects on social responsibility (Bielefeldt & Canney, 2014) and can help with engagement and retention of engineering students (Scherrer & Sharpe, 2020). Still, service learning should not be seen as a cure-all for broader, more embedded social issues; greater institutional change would be required for such a change (Butin, 2006; Hay, 2003; Zlotkowski, 1995).

Besides the research conducted on service learning, there is also a collection of studies on people's involvement with international projects through Engineers Without Borders-USA (EWB-USA). Compared to nonmembers, engineers involved in EWB-USA projects tend to exhibit a greater “openness to experience and agreeableness, stronger motivations for social good, and broader interests ...” (Litchfield & Javernick-Will, 2015, p. 393). Those in engineering practice (nonstudents) report being unimpressed with status quo engineering; they did not see it as a lifelong endeavor and appeared to be bearing with it until more meaningful work arose (Litchfield & Javernick-Will, 2017). Regarding female EWB-USA members, scholars found something of a contradiction: Females exhibited a greater potential for disillusionment with certain engineering careers (Litchfield & Javernick-Will, 2017) but also showed gains in areas that were identified as important for engineering persistence (Litchfield & Javernick-Will, 2014). (Some scholars, through psychometric methods, have developed—and made available—a tool and inventory for assessing social responsibility in engineers [Canney & Bielefeldt, 2016]. These measures are founded in concepts in an ethic of care philosophy and cover phenomena like personal social awareness, professional skills in relations to social considerations, and views on personal and professional obligation/responsibility.) Given that one's training is often an acculturation process, we review some social and educational theory that may be pertinent to this study.

2.2. Conceptualizing a Field of Collaboration

Social theorists have argued that one's acculturation, experience, and skills in certain fields—like engineering—play a determining role in one's *capacities* in those fields (Bourdieu, 1984; Swidler, 1986; Vygotsky, 1978). In other words, a stronger immersive experience in a particular field will result in one's greater capacity to reproduce the cherished skills and values of that field. However, in what Bourdieu (2007) calls *mismatch*, one's capacities in one field can prove a liability in another. For instance, a highly experienced professional, adept at both the substantive and institutional knowledge required to be a successful civil engineer in an engineering firm, may lack the cultural sensitivities required to work with a community group. We might expect then, in accord with such theories (Bourdieu, 1984; Swidler, 1986; Vygotsky, 1978), that the more experience one has with community groups—in what might be called *community group capital* or a *collaboration habitus*—the greater the successes resulting from community group collaborations.

In greater detail, Bourdieu's (1984) is a theory of fields, capitals, and a habitus, where fields are seen as sites of social struggle in the use of one's capitals (i.e., economic, cultural, social, and symbolic). These capitals are the currencies by which an individual navigates position, accumulates achievements, and gains status in a field. The habitus can be seen as the internalization of one's skills and capitals pertinent to a particular field.

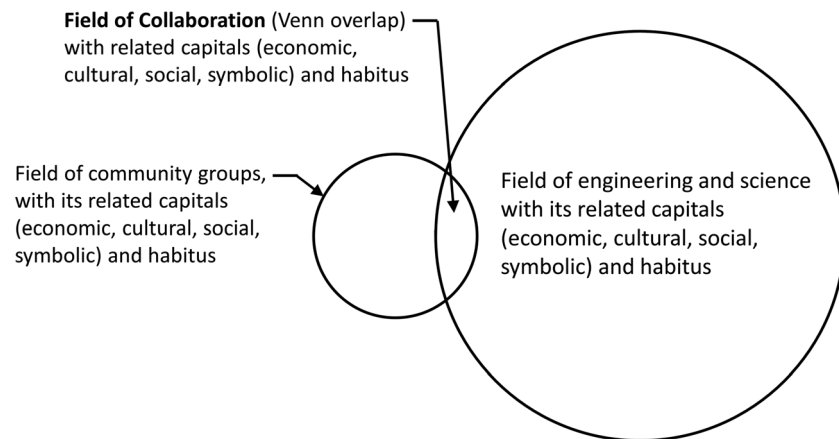


Figure 1. Field of collaboration with an economic emphasis, as might be theorized by Bourdieu (1984).

To illustrate how a theory of fields (Bourdieu, 1984) might apply to engineers and scientists and their collaborations with community groups, we present two figures in the form of Venn diagrams that propose a *field of collaboration*. We note that as there are many specialties of expertise within fields, these figures are only considered as general or ideal models. The size of the circles in the figures represents the volume of capitals in the respective fields. Figure 1 represents the fields of engineering and science versus community groups. On the right side of the figure is the large field of professional engineering and science (in academia, government, and industry); on the left is the smaller sphere of community groups. We construct this figure with an emphasis on economic capital and accordingly depict the engineering and science field as much larger than community groups. In a conceptualization like this, one that places high value on economic capital, it is not difficult to imagine that an engineer or scientist might consider themselves to be of higher status than someone from a community group (though not necessarily). In contrast, Figure 2, with similar sized spheres, has an emphasis on cultural capital in what we ideally propose would be the interaction of cultural and status equals. In other words, in the spirit of anthropological cultural relativism, this equal-sphered conception emphasizes that engineering knowledge and experience is no better than community group knowledge and experience.

In both figures, a field of collaboration is depicted as a smaller field in the Venn overlap. Consequently, each of the three fields—professional, community, and overlap—can be conceived as having its own set of capitals (economic, cultural, social, and symbolic) and related habitus. The field of collaboration, in turn,

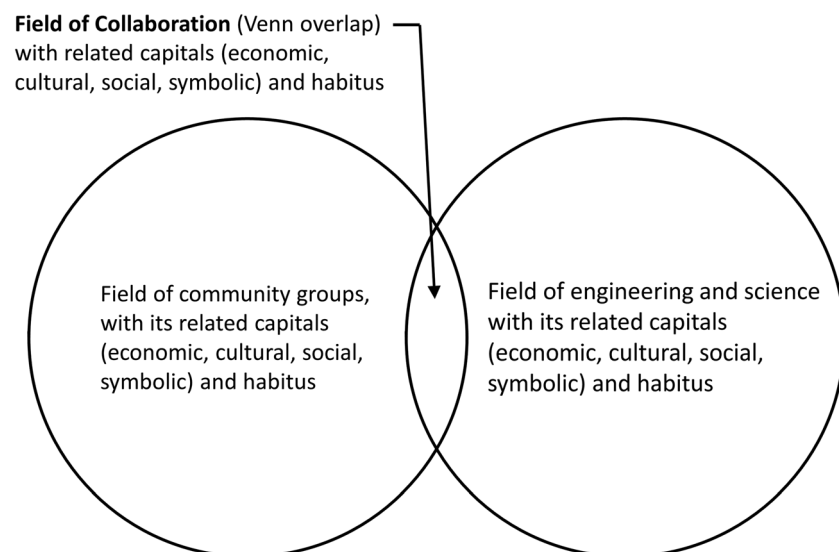


Figure 2. Field of collaboration, cultural emphasis, as might be theorized by Bourdieu (1984).

must be considered a more specialized field for all those involved. All those, then, outside of this specialized Venn overlap of collaboration can be seen as prone to mismatch (Bourdieu, 2007)—the disconnect between one's skills and contexts, or clashes with unfamiliar fields—as they are presumably unaccustomed to collaborative work.

As a type of companion to Bourdieu's (1984) theory, Swidler (1986) conceptualizes a *cultural toolkit*, and like the habitus, it is the internalization of strategies of action through which one successfully navigates specific cultures. Thus, like Bourdieu (2007), in what Swidler (1986) refers to as the high cost of retooling oneself, people generally avoid instances of mismatch. These cultural dynamics, along with the high-stakes and competitive nature of professional and academic life—see Slaughter and Rhoades' (2004) arguments on academic capitalism, leave little time and opportunity for engineers and scientists to engage in community based work.

Vygotsky (1978) also complements the work of Bourdieu (1984) and Swidler (1986) with the idea of the *internship*: the time-dependent mentoring and experiential learning absorbed through an experienced guide. The argument here is that those who are most successful in community type collaborations will be those who are mentored or modeled through the *experience* of an internship, which helps break through any knowledge, skill, or cultural barrier.

2.2.1. The Broader Context

From the broad view, we note that fields are not isolated spaces but can be nested within other fields and also have subfields within them (Fligstein & McAdam, 2012; Steinmetz, 2016). Accordingly, community group, engineering, scientific, and academic fields can be seen as nested within a much larger neoliberal, capitalist, and globalized field (Moore et al., 2011). Though the implications of such a field are beyond the scope of this study, its effects should be considered. For instance, researchers (Lave, 2012; Mirowski, 2011) have argued how science and the production of knowledge serving a for-profit marketplace can lead to the “narrowing of research agendas ... [to] focus on the needs of commercial actors” (Lave et al., 2010, p. 659). In turn, we can expect—as mentioned earlier (Kunda, 2009; C. W. Mills, 1956)—most engineers and scientists to be wholly captured within a particular topical area and its applications; we note that over 70% of engineers and scientists in the United States are employed in business or industry (NSF, 2017). This narrowing, then, contributes to what Frickel et al. (2010) refer to as “undone science” where certain—read, nonprofitable—research and development areas are overlooked and underfunded, like engineering and science to address environmental injustice. Thus, we can argue from the literature that much more effort is needed to redefine the values of a socioeconomic system that invariably places economic values over all others (Foucault, 2008; Marcuse, 1964). In short, though engineers and scientists are the focus of this research and affected by such grand forces, we do not expect them as individuals (singular limited agents) to offer deep insights or resistance to this grand field. We do, though, seek to learn from their views, their specific institutional positionings, and their experiences working with community groups. More specifically, we have chosen to focus on community group collaborations given their potential to build new forms of engineering and scientific practice that might address the challenges of communities facing injustices, rather than work done through other means or the public or private sector, which may or may not have direct or positive outcomes for such challenges.

It is through these literatures and with the aim of mobilizing engineers and scientists to collaborate with community-based groups working toward environmental, climate, and energy justice goals that we examine how those with technical expertise view their incentives, barriers, and potential for such collaborations and the possibility of building a consequent field of collaboration.

3. Methods and Data

3.1. Questionnaire Design and Data Collection

In order to realize our aims, we designed and implemented an online survey questionnaire using Qualtrics. Survey questions were informed by discussions with leaders of the Union of Concerned Scientists (UCS) Science Network and AGU's Thriving Earth Exchange as we sought to capture a variety of experiential and demographic data. (Items were also pretested by five participants at Arizona State University.) The final instrument, excluding demographic items, had a total of 35 questions and required about 15 minutes to complete. It was distributed between April and May of 2019 to email lists of the UCS Science Network, American

Association for the Advancement of Science (AAAS) Science and Technology Policy Fellows, AAAS On-Call Scientists, AGU Thriving Earth Exchange, and Science for the People. These lists have contact information for over 15,000 engineers and scientists, mostly residing and working in the United States, and many of whom are considered socially and politically engaged. We distributed to these email lists for two primary reasons: (1) The recipients come from a variety of engineering and science backgrounds, and (2) the recipients were likely to have diverse levels of experience.

3.2. Participant Incentive

Although respondents were entered into a raffle to win one of 10 gift cards worth \$50 each, no other compensation was given. Respondents were also asked for consent for use of their information for research, and the questionnaire was approved by the Institutional Review Board at Arizona State University. We hypothesize that socially engaged engineers looking for opportunities to participate would be more likely to respond to a survey about community-engaged work. Thus, even as there is self-selection bias, engineers and scientists in this group are the ones we want to learn from because of their possible previous experiences working on environmental, climate, and energy justice concerns and possible previous collaborations with community groups. Given the method of our sampling effort (email lists with a changing number of members), we do not have a viable/calculable response rate.

Our questionnaire surveyed engineers and scientists on two overarching themes: (1) the incentives and barriers important to doing community-oriented engineering and science and (2) their future potential to doing this work, including their resources, skills, and expertise, and the kinds of projects in which they have interest. To our knowledge, we are the first to document these deeper factors related to engineers and scientists and their paid or unpaid commitments to community-based work.

3.3. Data Imputation and Limitations

Of the 464 participants and the 275 fully completed surveys, we were able to retrieve 281 viable questionnaires, but there were still missing variables to address. We remedied a number of “one-off” type variables by imputing some data from other responses by the same participant, like assuming gender from someone's name or employment status from being retired. There were, though, larger clusters of missing variables with *political identity* (16 missing; 5.7% of sample) and *income* (26 missing; 9.3% of sample). To remedy the missing variables for political identity, we imputed the sample average of 1.77. For income, we used a more complex process: We imputed values by interpolating results from a linear regression model after we determined that a respondent's income had a significant association with their employment status and STEM experience. We note the following possible limitations: (1) Our sample was a purposive convenience sample with a degree of self-selection bias, and (2) from the coding of the barrier responses, we noted that different people might mean different things by community work and the different terms related to it. Community work could mean everything from phone banking, giving a public presentation, or water testing. Additionally, the barriers we coded as lack of knowledge or rapport (described later) for one person may not be the same as for another. Future research should measure such nuances more carefully. Finally, the fact that respondents identified barriers does not necessarily preclude or render these respondents ineffective in their community group work. We now give details on how we conducted the qualitative and quantitative analysis.

3.4. Quantitative and Qualitative Analyses

We analyzed the data using both quantitative and qualitative methods. After preparing the data and qualitatively coding some of the open-ended responses, we used binomial logistic regression to quantitatively explore the relationship between prior experience with possible incentives and reported barriers to community group work. Regression analyses tests whether mutual changes between variables can be considered significant and binomial logistic analyses are used when the variable of interest (the dependent variable) is a zero (0) or one (1), no/yes type response. A positive association between variables means that an increase in one is related to an increase in the other whereas a negative association means that an increase of one is associated with a decline in the other. We use this type of modeling to give us insight into what might be required and what factors should be considered to mobilize engineers and scientists for community-based work.

4. Results

In reporting questionnaire results, we created two descriptive tables of participant demographic data (see Tables S7 and S8 in the supporting information). Overall, most of the sample—over 53%—identifies as male, White, is employed, earns over \$70,000 per year, and has over 20 years of STEM experience. 72.2% have experience working with community groups. Geographically, these participants are located in 45 different states in the United States, with the largest single concentration, at 14.9%, in California. The next four states by concentration are Massachusetts (6.0%), Oregon (5.7%), New York (5.3%), and Washington (4.6%). Regarding how respondents received our questionnaire, a great majority, 68.0%, received it through the UCS' Science Network, while 8.9% and 5.0%, respectively, received it through AAAS Fellows and the Citizen Science Association Listserv where our questionnaire was forwarded to. The remaining 18.1% received it through an assortment of six other sources.

4.1. Incentives

Regarding incentives that respondents cited for community engagements, we first identified respondents who claimed they had prior community group experience and then examined how they responded to questions on: (1) Were they able to use their STEM skills? (Though it may be difficult to conceive of skills as incentives, cultural scholars (Swidler, 1986, p. 273) have referred to them as “strategies for action.” In other words, one's incentive toward a particular end as influenced by one's capacity to achieve it, or sense of efficacy.) (2) Were they funded? (3) What is the source of their funding? After descriptively examining these variables, we logistically regressed the first two questions and graphically display the third.

Regarding frequency data (see Table S8, supporting information) for the 72.2% of our sample with community experience, 84.7% claimed that they used STEM related skills in this work; 9.9% responded that they only had experience with *paid* community work; 50.7% had experience with only *unpaid* work; and 38.4% had experience with both paid and unpaid work. (We note that nonresponse rates for these items were minimal; less than 3.0%.)

4.1.1. Logistic Regression

Table 1 displays the results of five binomial logistic regression models, each regressed on a collection of demographic variables, from more individual to more institutional. Model 1 is for prior experience with community groups; model 2 is for current work includes community groups; model 3 is for those using STEM related skills; model 4 is for the respondents who only had experience with paid community work; and model 5 is for those who experienced only unpaid work. Each of these dependent variables conforms to the (0, 1) binomial type and are regressed upon the same set of variables ranging from the attributes of one's individual identity, the employment sector, and years of STEM experience. (As the sector variable is a mutually exclusive variable—a respondent could not be in two categories at once—we created dummy variables for each sector type response and we dropped a referent category—*retired*—in order to operationalize the model. *Retired* was chosen as it seemed to be the greatest outlier; Retired persons are generally the eldest, potentially unemployed, and more likely to be biographically available—have more time—for community type interactions.) In all of these models, 1–5, the Nagelkerke *R*-square—ranging from a low of .104 to .238—is of moderate strength and the Hosmer and Lemeshow test—meant to identify poor modeling—is insignificant, which indicates that there are no significant issues with model goodness-of-fit.

In model 1, for those who responded “yes” that they had community group experience, there are significant negative associations—while controlling for other factors—for White and income. Also, relative to being retired, all the sectors, *Students* and *Other* aside, have a significant positive association with community work. Years of STEM experience also has a significant positive association with prior community group experience. For model 2—“current work includes community groups,” this question was only directed at those responding as employed ($n = 179$); hence, the absent variation for employed in that model. There are significant negative associations with STEM degree and income but significant positive associations with years of STEM experience.

In model 3, use of STEM skills, there is only one significant association, and it is positive for years of STEM experience. In models 4 and 5, we examine those who claimed they only had experience with paid or unpaid community work, respectively; we do not analyze those who have experience with both. In model 4, there is only one significant association with paid work, and it is negative for income. In model 5, there is a positive

Table 1

Binomial Logistic Regression: Prior Experience With Community Groups, STEM Skills Used, and Paid/Unpaid Work Regressed on Demographic Variables (Standardized Coefficients)

	Model 1: Prior experience with community groups	Model 2: Current work includes community groups	Model 3: Use of STEM skills	Model 4: Paid work	Model 5: Unpaid work
(Constant)	1.132 ***	−0.061	2.766	−4.936	0.138
Male	−0.212	−0.124	0.083	−0.004	−0.024
White	−0.307 *	0.130	0.122	0.353	−0.115
Income	−0.502 ***	−0.353 *	−0.100	−0.614 **	0.632 ***
Employed	−0.351	--	−0.295	0.347	−0.432
Political Orientation	−0.232	0.062	−0.139	−0.143	0.063
STEM Degree	−0.196	−0.706 **	−0.098	0.383	0.277
Student	0.043	−0.296	0.230	−5.580	0.104
Education Sector	0.869 ***	0.135	0.545	−0.058	−0.235
Business Sector	0.704 **	0.090	0.198	−0.536	−0.143
Government Sector	0.643 **	0.203	0.718	−0.098	−0.185
Nonprofit Sector	0.673 **	0.403	0.358	0.370	−0.823 ***
Other	0.283	−0.017	4.071	−3.887	−0.093
Years STEM Experience	0.376 *	0.379 *	0.536 *	−0.119	−0.716 ***
Nagelkerke R-Square	0.180	0.203	0.104	0.238	0.230
Hosmer and Lemeshow Test	0.417	0.990	0.909	0.207	0.709
Number of Observations	281	179	198	201	201

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

significant association between income and unpaid work and significant negative association with both the nonprofit sector and years of STEM experience with unpaid work.

Figure 3 depicts the reported funding sources of those who claimed they had previous experience with paid community work ($n = 98$). (Of the $n = 98$ respondents to the source of paid funding question, 4.1% ($n = 4$) did not respond. This leaves $n = 94$ respondents in Figure 2.) We note that no single source dominates this figure, but if federal and state government sources were conjoined, these would be dominant. There was a small number of miscellaneous mentions in the *other* category: a mix of personal, private, university, and other sources.

4.2. Barriers: Qualitative and Quantitative Analyses

Prior to conducting quantitative analyses of the responses to perceived barriers, two of the open ended questions were qualitatively coded and examined using grounded textual analysis. These questions

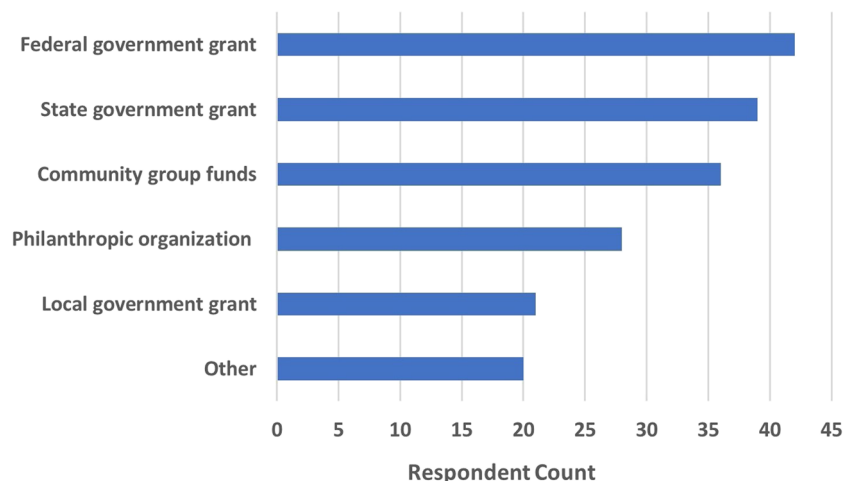


Figure 3. How previous paid community work was funded.

Table 2
Highlights of Qualitative Coding and Clustering Into Themes

Theme	Code	Description	Instances
Lack Rapport	Lack of rapport	For example, “We do not really get along well.” Similar to a culture gap.	57
	Hapless groups	For example, “These groups do not really know what they are doing.”	13
		<i>Lack rapport total</i>	70 (26.9%)
Knowledge Deficit (Lack of Knowledge)	Unawares	For example, “I do not know of any community groups with needs.”	32
	Do not know how	For example, “Do not know how to work with community groups.”	17
	Skills disconnect	For example, “Do not know how to connect my skills with a community group.”	20
		<i>Knowledge deficit total</i>	69 (26.5%)
Lack Time	Lack of time	For example, “I’m too busy for it.”	52 (20.0%)
Lack Funds	Lack of funds	For example, “I’m not funded enough for it.”	36 (13.8%)
Unrecognized Value	Unrecognized value	For example, “Working with community groups is not a recognized value where I work.”	13 (5.0%)
Collaboration Burden	Collaboration burden	For example, “To do this well, to collaborate well, the amount of effort required on both sides, is too much to consider.”	11 (4.2%)
Other (Personal and Political)	Personal & political	A mix of personal reasons and political/institutional challenges.	9 (3.4%)

(see supporting information) were Q21 (which asked for a more experiential response) and Q49 (a more aspirational response) and are as follows:

- Q21. Have you experienced any barriers in finding opportunities to work with community groups? (For example: lack of knowledge about projects, difficult to connect to communities, do not know how to apply technical skills in this work, etc.) Please explain. _____.
- Q49. How would you like to see community-based work valued and supported within your institution and/or more broadly?

For Q21, Table 2 is used to clarify this process of coding and categorization, where there are themes in the first column, codes in the next column, then descriptions of codes, and, to the far-right, the aggregated number of instances for the code. We note that some of the themes—like lacking rapport and knowledge deficit—were more of a clustering of codes that required more detail, whereas some were more directly referenced, like not having enough time or funding. We also note the percentage of instances referenced by respondents in the last column to the right, with lacking rapport and knowledge deficit as the most highly referenced codes, both at 27%, and lacking time (20%) and funds (14%) following close behind.

We also note, in Table 2, how other codes were more directly referenced, like for “Do not know how” (knowledge deficit), one respondent replied, “I do not know how to connect with community groups in my area” However, other themes required a more creative approach to coding, like this response coded as both knowledge deficit and lack of rapport, “Community groups are narrowly focused and tend to fail because of flawed models they do not understand.” A number of respondents identified the community group itself—besides other things—as a barrier to their greater involvement in community group work; these types of responses were coded as “hapless groups” and are detailed further below.

The theme *lack of rapport* is a collection of responses that went from *hapless groups*—a reference actually used by a respondent, who scripted community groups as being incompetent—to a lack a trust between engineers and community groups, to cultural differences and differing approaches to, and perspectives on, a particular community problem or issue. Lack of rapport, as a theme, also included the amount of time that some respondents said was required to build rapport itself. Moreover, narratives that framed community work as requiring much relationship-building time seemed to script a backdrop of wisdom, experience, and understanding that good rapport with community groups was necessary and that collaborations required time and commitment and should not be taken lightly. There were a number of notable responses regarding rapport, which ranged from critique to observation, like, “You have to follow their priorities” and “These groups started with lack of trust, suspicion of motives, fear of regulation.” There was also one respondent who sounded defensive:

A couple of environmental organizations are pretty convinced of their approaches and disagreements are not easily accepted. This in spite of my PhD and a minor in economics giving me the creds to at least disagree.

Table 3
Binomial Logistic Regression: Five Models, From “No Barriers” and Barriers Regressed on Demographic Indicators (Standardized Coefficients)

	Model 6: “No barriers”	Barriers			
		Model 7: Lack time	Model 8: Lack funds	Model 9: Lack rapport	Model 10: Knowledge deficit
(Constant)	−3.090	−1.177***	−2.053***	−1.045***	−1.760
Male	0.248	−0.070	−0.338	−0.012	−0.053
White	−0.328*	0.086	0.612**	−0.077	0.075
Income	0.396*	0.400*	−0.270	−0.007	−0.061
Employed	0.530	0.233	0.455	−0.330	−0.621**
Political Orientation	−0.158	−0.062	0.124	0.164	0.230
STEM Degree	−0.598***	0.171	−0.166	−0.102	0.464*
Student	−5.821	0.521**	0.272	0.532**	0.248
Education Sector	−0.981**	0.000	0.682*	0.550*	0.542*
Business Sector	−0.793**	−0.198	0.140	0.636**	0.715**
Government Sector	−0.994***	0.035	0.206	0.143	0.600**
Nonprofit Sector	−0.597*	0.113	0.536*	0.524**	0.249
Other	0.072	−0.082	0.339	0.012	−3.971
Years STEM Experience	0.580*	−0.201	0.377	0.119	−0.223
Prior Community Experience	0.573**	0.210	0.751**	0.259	−0.299*
Nagelkerke R-Square	0.332	0.150	0.259	0.121	0.162
Hosmer and Lemeshow Test	0.957	0.758	0.422	0.850	0.438
Number of Observations	199	199	199	199	199

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

However, there were also respondents who were critical of the approach of scientists and engineers with scripts critiquing a type of incompetent superiority complex, like “Lack of intentional approaches to community-based STEM work. It’s sadly often conducted in a white savior manner.” In this vein, another respondent wrote, “Non-Native senior PI’s, Hubris of myopic science.” Though there is a way that lack of rapport can be framed as a knowledge deficit (people not knowing how to collaborate; explained more in the following paragraph), we have distinguished these two themes, with rapport referring more toward interpersonal and/or relational issues and knowledge deficit more to do with lacking substantive skills or awareness in finding networks or connecting one’s expertise with the appropriate group.

To clarify, the theme *knowledge deficit* is a collection of codes that range from complete unawareness of local community groups to not knowing how to work with them and to what we term a “skills disconnect,” which is not knowing how to apply or find the right outlet for one’s particular expertise. Thus, some respondents said, “Unsure of how to start working with communities,” and another said, “I know there are lots of organizations and projects, but I have not found a central place where I can find them. I mostly find out about projects by word of mouth.” Also, someone who was retired wrote, “Being retired, I am out of the academic loop, to a certain degree.” Regarding a *skills disconnect*, some respondents wrote items like, “Not able to apply technical skills into a community group setting” and “Yes, I’ve found very few community groups or nonprofits who hire or use scientists (they usually want organizers, fundraisers, executive directors, etc.).” Thus, the theme of *knowledge deficit* runs a range of phenomena from complete unawareness of community groups to a skills disconnect on how to apply one’s skills. We also note that when using the term, “knowledge deficit,” we intentionally invoke some of its critics (Hansen et al., 2003; Schultz, 2002), who assert that the provision of information does not, in and of itself, guarantee a changed behavior. We have some evidence of this in this study as some respondents expressed that they knew how to connect with community groups but still considered the demands to be too great. The nuances of this specific finding, though, deserve more research.

4.2.1. Binomial Logistic Regression Analyses

Table 3 depicts the results of five binomial logistic regression analyses ranging from: those respondents who claimed to have no barriers “in finding opportunities to work with community groups” (model 6) to four models of the qualitatively coded barriers grouped into themes of lacking time (model 7), lacking funds (model 8), lacking rapport (model 9), and a knowledge deficit (model 10). Note: the sample size for these

Table 4
Descriptive Statistics—Community Group Engagement, Interest, and Possible Contribution

	<i>n</i>	Min.	Max.	Mean	Std. Dev.	Mean Yearly Total (hr)
Currently Engaged in Comm. Work	267	.00	1.0	.386	.488	--
Interest in Local Comm. Work	281	1.0 (Not interested)	5.0 (Extremely interested)	3.775	1.059	--
Interest in Distant Comm. Work	281	1.0 (Not interested)	5.0 (Extremely interested)	2.809	1.129	--
Current Comm. Work (hr/week)	102	1.0 (0–2 hr/wk)	6.0 (More than 10 hr/wk)	3.168	1.985	16,803
Could Contribute With Local Comm. (hr/week)	281	1.0 (0–2 hr/wk)	6.0 (More than 10 hr/wk)	2.403	1.541	35,113
Could Contribute With Distant Comm. (hr/week)	281	1.0 (0–2 hr/wk)	6.0 (More than 10 hr/wk)	1.886	1.405	27,558

Note. Source: Authors' own data.

models is $n = 199$ because not all participants answered this question: “Have you experienced any barriers in finding opportunities to work with community groups? (Q21, see supporting information). This means that of the $n = 281$ respondents, $n = 82$ (29.2%) did not respond. Moreover, of these responses, only $n = 46$ (23.1%) replied that they did not experience barriers in opportunities to work with community groups (which equates to only 16.4% of the total sample). Thus, $n = 153$ (76.9%) did identify some form of barrier. In all of these models, the Nagelkerke R -square ranges from strong (0.332) to moderate (0.121).

For model 6, we find that being White and having a STEM degree have a strong negative significance with claiming “no barriers.” Additionally, for all the employment sectors—Student and Other aside—relative to being retired, they also have strong negative associations with the no barriers response (model 6). There are only two significant positive associations in this model, and they are strong: years of STEM experience and those with prior community group experience. In model 7, for respondents that referred to a lack of time as a barrier, there are only two significant associations, both strong and positive: Income and Student. In model 8, for those reporting a lack of funds, there are three significant associations and all strong and positive: White, the Education sector, and those with prior community experience. For model 9, lacking rapport, there are four significant, strong, and positive associations in only the sector categories: Student, Education, Business, and Nonprofit sectors. In model 10, knowledge deficit, there are strong, positive, and significant associations for STEM degree, and the Education, Business, and Government sectors, and there are strong, negative, significant associations for Employed and Years of STEM experience.

4.3. Potential

Finally, we describe the coded responses to an open-ended aspirational question on how respondents would like to see community-based work valued and supported in their institutions. Most (44.9%) of the $n = 156$ participants who responded to this question (this is a limitation; only 44.9% of our sample responded to this question) simply “desired for it to be more valued and/or encouraged in their institutions.” This was followed by desires “for more time and/or funding” (35.3%); “more formal institutional structures where one could easily engage with communities” (28.2%); and “help with creating and maintaining community group relationships” (28.2%). Other responses referred to a desire “that institutions help augment knowledge and educate participants on community issues” (23.7%) while others wanted “to be personally more recognized by their institutions for the work they did” (16.0%), and some mentioned that “institutions had an ethical and essential obligation toward communities” (12.8%).

In this section, we review findings with respect to present engagements and interest in (both local and remote) community group work. Table 4 presents six variables from current engagement to possible contribution. An estimated 38.6% of those who responded as employed (63.7% of all respondents) are currently engaged in community work. When comparing the means of responses, as might be expected, we see there is less interest in working remotely than locally. In the far-right column are yearly totals of the potential hours respondents said they could contribute for community work. From this $n = 281$ sample, we see that in the second to the last row, over 35,000 hr per year could be contributed to local community work.

In a set of ordinary least squares analyses, Table 5 contains the results of five variables related to community group work regressed on demographic variables. These models examine interest in (models 11 and 12; local and distant), current work in (model 13), and possible contributions to (models 14 and 15; local and distant) community group work. From the adjusted R -squares, we see that model 11 has moderate strength and the

Table 5

Linear Regression: Five Models, From Prior Experience With Community Groups to “No Barriers” and Barriers Regressed on Demographic Indicators (Standardized Coefficients)

	Model 11: Interest in local community work	Model 12: Interest in distant community work	Model 13: Current community work hr/week	Model 14: Could contribute locally hr/week	Model 15: Could contribute at distance hr/week
(Constant)	***	***	***	***	***
Male	0.038	0.024	0.002	0.006	−0.005
White	0.058	0.028	0.016	0.059	0.018
Income	0.008	−0.117	−0.194	−0.053	−0.104
Employed	0.071	−0.108	0.104	−0.172	−0.094
Political Orientation	−0.059	−0.009	−0.091	0.069	0.138**
STEM Degree	0.036	0.039	−0.102	−0.087	−0.110*
Student	0.072	0.224**	−0.044	0.008	−0.013
Education Sector	0.123	0.306***	−0.161	−0.050	−0.028
Business Sector	0.000	0.235**	−0.023	0.012	−0.046
Government Sector	0.074	0.270***	−0.036	−0.039	−0.019
Nonprofit Sector	0.036	0.266***	0.199	0.126	0.117
Other	0.037	0.101	0.041	−0.024	−0.004
Years STEM Experience	−0.252***	−0.059	0.195	0.108	0.186**
Prior Community Experience	0.289***	0.118*	0.204**	0.178***	0.089
Adjusted R-Square	0.179	0.087	0.074	0.075	0.067
F Value	5.369***	2.901***	1.579	2.617***	2.426***
Number of Observations	281	281	102	281	281

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

remaining models are weak in strength. The F value in model 13 (the smallest sample size, $n = 102$) is also insignificant adding to the weakness of this model although there is, in model 13, a significant positive association between prior community experience and current hours per week spent in community work.

Overall, in all these models, experience aside, many of the variable associations are insignificant. Regarding experience, except for model 15, there is a significant positive association between prior community experience and all the independent variables; in model 15, it is STEM experience that is significantly positive. This finding emphasizes the strong relations between experience and increased community group interest and possible contribution. In model 12, we note the clustering of significant positive associations in the sector category. This suggests that compared to these sectors, those who identify as retired have less interest in distant community work. We also note in model 15 a significant positive association for political orientation, suggesting that those who—relatively—identify as less liberal are more inclined to contribute to distant community work. Also, in model 15, there is a significant negative association with STEM degree, suggesting a type of barrier that a STEM degree may have—at least in this multivariate analysis—regarding one’s time contributed to distant community work.

5. Discussion

When reviewing our results, there appears to be an argument for the differentializing effects of race, class, and experience in this sample ($n = 281$) of engineers and scientists and their self-reported engagements with community groups. Through multivariate analyses of incentives, barriers, and potentials, we note that the variable White—while controlling for other factors—is less associated with both having prior experience with community groups and making the claim that there are no barriers to working with community groups. It appears, then, that whiteness creates some form of impediment to community group work. It is not unknown that whiteness—or White privilege—is associated with a type of ignorance in its bearer (McIntosh, 1988; C. Mills, 2007; Mueller, 2017); perhaps, this dynamic is at play in this finding. People who responded as White are also strongly associated with the “lack funds” barrier, while White is inconsequential to other barriers and potentials. We are not sure how to interpret this, except at its face value: Those

responding as White are significantly more likely to claim that they lack funds for community work. Do Whites have higher expectations? Are they not aware of alternative resources? Do they see funding barriers where others do not? Might this speak to a lack of knowledge or is it an insight concerning scarce funding sources? It is difficult to know without more research.

Income also plays a significant role in our findings, as it is negatively associated with prior and current experience with community groups and *paid* community work, but is positively associated with unpaid work, “no barriers,” and “lack of time.” (There appears to be tension between income and STEM experience, as they are positively associated in bivariate relation, but in model 1, they are negatively associated. What appears to be happening is that in the multivariate model for prior experience with community groups, the income and STEM experience relation is split and experience overrides effect of income.) This, interestingly, suggests that relative to other variables, personal income does not contribute to greater engagement in community work (like more years of STEM experience does), but it does relate to the amount of unpaid work conducted by a respondent. It appears, then, that personal income might play something of a substitute for shortfalls in institutional funding. Regarding the positive associations between income and the “lack time” barrier, this may be related to the greater time demands placed on those of higher income (Hochschild, 1997; Schor, 1999) or the “higher understanding” of the demands of community-based work and thus the subsequent view that one does not have the required time for it. Possibly, it might mean that those who *cannot* complain about a lack of funding *can* complain about a lack of time, but this is speculation and should be subject to further research.

5.1. Experience

Experience played the most salient factor in our findings in the form of two variables: years of STEM experience and prior experience with community groups. These related associations suggest that greater knowledge—experiential knowledge—augments one's connections with community groups. Unpaid work and knowledge deficit aside, these experience variables play a positive, or at least inconsequential role, in all the models. Years of STEM experience has a positive relation to prior experience with community groups and both these experience variables have positive associations with the claim of “no barriers.” Regarding potential interests, STEM experience is negatively related to the variable “interest in local community work,” but positive with “could contribute to a distant community group,” and again, experience with community groups is in positive relation to nearly all potential interests. There appears to be, then, a type of cause-effect loop or acceleration effect between experience and community group work: as one increases so does the other. Bielefeldt and Canney (2014), who, distinct from us, only study engineering students, seem to have similar evidence for this in their first-year students: Those with more high school service-learning participation reported higher levels of social responsibility. As reviewed above, we also found positive associations between experience and community engagements and the reporting of “no barriers.” Additionally, there is nuance in these relations. For instance, a STEM degree is negatively associated with community work while STEM experience is not, suggesting that in our study, STEM experience overrides formal education with respect to community engagements.

Experience is often a marker of knowledge in a field, and as is known, employers often desire people with greater experience. Additionally, those engaged in an activity are usually more confident when they have experience in that activity. This strong salience of experience may also be—in relation to those retired—suggested by the sector variables, which at times vary together, negatively in relation to the claim of no barriers and positively with lack of rapport and knowledge deficit. However, the more negative relation between retired and prior experience with community groups seems inconsistent with this finding and may reflect a generational cohort effect, which means that those from another generation may be less culturally prone to work with communities. Those who responded as retired also had the least interest in distant community work, which suggests a more local preference. Regarding the other sector variables, those in education or with a nonprofit organization were significantly more inclined to say they lacked funds for community work. This might be reflective of the need for academics engaged in research and those in nonprofits to constantly find funds to support their work. Also, in a seeming twist, those who were employed by a nonprofit group also expressed less experience with unpaid work, but this might be because they conflate their views of nonprofit and community work. All of these sector findings, though, should be confirmed by more research.

5.2. Interpreting our Results Through Field Theory

We appear, then, through our findings on experience, to have evidence for a *field of collaboration* between engineers, scientists, and communities: where more experience in collaboration—something like a collaboration habitus and an increase in one's social capital (Bourdieu, 1986)—without saying, makes one better at collaboration itself. Thus, the sooner an engineer, for example, begins to experience a field of collaboration, the sooner they will augment their skills in collaboration. Additionally, our findings show evidence for the concept of *mismatch* described earlier: Having a STEM degree is negatively associated with “current work includes community groups” and the claim of “no barriers,” while there is also a positive association with a knowledge deficit. This finding is reminiscent of work by Valenzuela (1999), who finds a “subtractive” process in a study of U.S.-Mexican youth during their acculturation into U.S. schools. While attending U.S. schools, she argues that students discounted or abandoned parts of their Mexican cultural heritage. Perhaps, then, as other scholars have argued (Canney & Bielefeldt, 2015; Cech, 2014), a STEM degree can diminish one's community concerns through the educational process itself.

Returning to the concept of mismatch (Bourdieu, 2007) or its opposite, well-matched, its presence may be seen in the way more experience with community groups—in what might be called *community group capital* or a *collaboration habitus*—is more positively associated with more community-based work itself. The challenge, though, for those interested in community-based work is that the subtractive process might impact one's scientific or engineering standing, and other studies have also argued this point (CSD, 2016). This idea, though, does deserve more research.

5.3. Recommendations

Responding to our findings and discussion, we offer recommendations for the development of a field of collaboration for engineers, scientists, and community groups. We do so by first asking questions to create an epistemic framework; these questions spring from our findings—lack of time, funds, rapport, and knowledge—and also Bourdieu's (1984) ideas on fields, habitus, and capitals—economic, cultural, social, and symbolic.

1. What resources are most effective in generating a field of collaboration? More concretely: What are the rewards for which people enter this field, or the incentives driving collaboration? What is the valued substance, currency, or vehicle by which community collaborations will self-sustain?
2. Are there, then, institutionally recognized, valued, and ultimately, sponsored programs that can be designed and implemented to overcome the existing barriers to community collaborations, and at larger and larger scales of impact?

In offering recommendations, we recognize the interdependent nature of the capitals in field theory (Bourdieu, 1986). For example, finding time and funds for collaboration are highly related and time is also helpful to create rapport and resolve knowledge gaps. We also note that we would not be asking these questions or conducting this research if the struggles of communities—technical or otherwise—were already being systematically addressed through a combination of public services and policy, a viable and economically sustainable marketplace, and some form of a normalized cultural practice within engineering and science. Finally, we note that—in response to the generally individualized and ad hoc nature of existing community collaborations—there are five primary institutional domains to which our recommendations are targeted: governments, corporations, academia, philanthropy, and professional associations. We invite others to strategize with us on how to generate and sustain a field of collaboration.

5.3.1. Funding

Considering three related phenomena—(1) the lack of funding identified by our respondents, (2) a neoliberal socioeconomic context and its effects, and (3) the unlikely chance that a regulatory state will rise up and induce a market response to community challenges—we must turn to more creative cultural and institutional means to monetarily support engineers and scientists who desire to work with community groups. It is those with the greatest economic capital—governments, corporations, academia, and philanthropy, each with their particular influences and limitations—that should advance the greatest commitments. Pilot projects and experiments with the goal of understanding how to fund this work in a financially sustainable manner can create the possibilities of a larger marketplace for community-based work. Creating sustainable

business models to hire enthusiastic engineers and scientists also appreciates the diversity of engineers and scientists who want to engage in this kind of work without expecting all of them to bear the risks and uncertainty associated with entrepreneurship. Considering the tens of thousands of hours (see Table 4) that our respondents are willing to contribute and the few financially viable careers addressing these challenges, any paid model of community-based work would likely be received enthusiastically by engineers and scientists.

5.3.2. Cultural and Symbolic Measures

Lacking viable financial models at the moment, there may be pathways to operationalize cultural and/or symbolic measures, measures not completely disconnected from funding. Such pathways can include awards and prizes for community engagement—like The Constellation Prize (2020), which seeks to highlight how community-based engineering can promote environmental protection, social justice, peace, and human rights—and greater recognition for such work in annual evaluations for those who work in the private sector and in tenure reviews for academics. As universities attempt to normalize a service learning culture for students, a similar practice could be established for both professional engineers, scientists, and academics. Corporations can require community-based training for their engineers and scientists to strengthen the notion of corporate social responsibility. We also note that though universities, companies, and other organizations may symbolically present themselves as serving the needs of communities through environmental or other social commitments, the reports from our respondents did not fully corroborate such efforts (e.g., a lack of time and funding). Perhaps then there is the opportunity for oversight to verify such claims to communities.

Professional associations might also strengthen the cultural capital of community collaborations by redoubling their efforts in recognizing this work. As mentioned in our introduction, existing initiatives like AGU's Thriving Earth Exchange (AGU, 2020), AAAS's On-Call Scientists (AAAS, 2019), and the Union of Concerned Scientists Science Network (UCS, 2020) can be expanded. Additionally, professional conferences that highlight and support community-based science and engineering—for example, American Geophysical Union's Annual Meeting (AGU, 2019) and the AAAS Science, Technology, and Human Rights Conference (AAAS, 2019)—can continue to assure their recognition of and commitments to community collaborations. For example, in such gatherings, every effort can be made to have equal numbers of community group leaders on the one hand, and engineers and scientists on the other.

5.3.3. Education, Mentoring, Workshops, and Knowledge Sharing

As our respondents recounted a range of challenges, from lacking knowledge of community groups to how to work with them and apply their skills, a broad range of educational initiatives can be implemented, for example, from cultural competency training to more formal educational programs. Presently, there is a laudable number of small but growing humanitarian engineering programs at universities (Asfa-Wossen, 2020), but greater recognition might be drawn to these programs by developing a certification system. For instance, just like there are *Certified B Corporations* (B Lab, 2020) for certifying sustainable corporations and just like how a nonprofit organization called Sustainable Jersey (2020) certifies municipalities in the U.S. state of New Jersey in their efforts to reduce waste, cut greenhouse gas emissions, and improve environmental equity, an oversight body could be developed to certify not only certain departments and colleges but universities themselves regarding their degree of commitment to community-based collaborations. This might even create some form of competition between different universities.

Those who are more experienced in community collaborations—if adequately supported—could strengthen the cohesiveness of their social networks, build information hubs, design educational workshops, and commit to mentoring activities and internship programs for more inexperienced but interested engineers and scientists. These efforts can address the lack of knowledge engineers and scientists may have to thoughtfully collaborate with communities facing injustices, being mindful of the justifiable skepticism many communities have engaging with engineers and scientists, as we described earlier (Brown et al., 2019).

Knowledge sharing can also happen through other institutional mechanisms. For example, funding organizations like the U.S. NSF and U.S. National Institutes of Health (NIH), organizations that have funded community-based science and engineering (see, e.g., the *Smart and Connected Communities* program by the NSF, 2016, and the *Community-based Participatory Research Program* of the NIH, 2018) can make it easier for researchers interested in such work by synthesizing modes of engagement used across their funded grants and point new researchers to ways in which others have incorporated community-based

collaborations in their work. This can make it easier for researchers to build from existing knowledge and practice, rather than first-time learning and possibly failing at their goals.

5.3.4. Different Sectors, Different Responses

We note from our findings that the sector variables suggested a split between economic and some cultural and symbolic values. For instance, members of the education and nonprofit sectors—sectors that may be more attuned to the cultural and symbolic value of community collaborations—were significantly more inclined to say that they lacked funds for community work. In contrast, the business and government sectors seemed in relative less need of funds and greater need of community symbolic incentives. Though this assertion is deserving of further research, we propose that businesses and governments could culturally and symbolically incentivize the benefits of community group collaborations (since they seem to have the funds to do so), while any and all funding bodies could direct more monies toward the education and nonprofit sectors.

5.3.5. A Focus on Retired Persons

Respondents who claimed to be retired, our largest response category (29.5%; see Table S7), appear to be a large untapped resource. Any creative efforts to nurture and support collaborative skills in the retirement community could be aggressively pursued. This can include, again, a culture-symbolic incentivizing by organizations like the American Association of Retired Persons, Encore, and others whose engineering- and scientifically-minded members may be seeking new ways to engage in society. Importantly, those who are retired and economically secure might have both time and financial resources at their disposal.

Finally, we would be remiss to not encourage a greater social movement and set of institutional demands springing from the ranks of engineers, scientists, and academics themselves. Such a social transformation like that which we are recommending requires efforts from all quarters and institutional levels. We also note that a concerted effort that advances community-based work in multiple sectors at once is most necessary, or misalignments might ensue. For example, as Florman (1997) alludes, training someone with a certain set of skills for which there is no context of use may be a fruitless endeavor. Thus, the universities that train students must work hand-in-hand with the sectors of society that will employ those students in the future. In short, a new field of collaboration will espouse and express new cultural values, create and spread new resources, and incentivize new means of self and collective support. We might possibly imagine participation in a field of collaboration as meeting its own need, like collaboration for its own sake. In other words, the way a collaboration habitus would seek to reproduce its own self.

Further research could more deeply explore the race and class dimensions of our findings. Research could also address fundamental questions like: Why do underserved communities have engineering and science challenges in the first place? Why do the injustices exist at all? In an ideal world with the appropriate implementation of laws and policies, would such community challenges exist? We acknowledge that there is a long history of research on environmental—and more recently, climate, and energy—injustices in the United States. As the onus to investigate and remedy such challenges cannot solely be placed on individuals, we call for greater commitments—even beyond research—from all institutional levels of society: universities, governments, firms, philanthropic organizations, and professional organizations.

6. Conclusion

In this research, we sought to examine the incentives, barriers, and potential of engineers and scientists working in diverse contexts with respect to their engagements with community groups. From a purposive convenience sample of $n = 281$, and while controlling for other factors, we identified dynamics of race, class, and experience, where whiteness and greater personal income have negative associations with community work. Personal income, however, possibly substitutes for a lack of institutional funding. We also found that experience—suggesting greater knowledge—has positive associations with community group work and its future potential, and we identify four thematic barriers to community engagements: lack of time, lack of funding, lack of rapport, and knowledge deficits.

Leveraging field theory (Bourdieu, 1984), we hypothesize what a *field of collaboration* between community groups, engineers, and scientists might look like. We offer recommendations on how this field of collaboration might be supported and sustained. As a lack of community group rapport and knowledge deficits were salient, we call for a greater emphasis on the creation of social networks and educational programs directed at community collaborations. We also call for greater organizational and institutional investments in

community work, to complement individualized efforts, and a heightened attention to the cultural and symbolic dimensions of community engagements. In other words, in addition to building economic models that support community-based engineering and science, a greater sense of cultural value should imbue these collaborations between engineers, scientists and their community-based partners in order to address longstanding issues of energy, climate, and environmental justice in the United States.

Data Availability Statement

The data for this study can be found in a Mendeley data repository at doi: 10.17632/b6252s2dzc.1 (<https://doi.org/10.17632/b6252s2dzc.1>).

Acknowledgments

We would like to thank our publication reviewers for their support and guidance. We want to thank all of those who participated in our survey. Part of this research was conducted with the support of National Science Foundation Award 2016108.

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