Evaluating the Quality of Project Summaries for S-STEM Proposals

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Abstract

Rice University received funding from the National Science Foundation (NSF) to host workshops designed to help faculty members at predominantly undergraduate institutions (PUIs) develop competitive proposals to the Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program. S-STEM projects provide scholarships and other support to low-income students who demonstrate the academic potential to succeed in STEM disciplines with the aim of increasing their presence in the U.S. STEM workforce and/or graduate programs.

Our recruitment efforts focused primarily on PUIs located in Experimental Program to Stimulate Competitive Research (EPSCoR) jurisdictions. An initial search of NSF's awards database showed that despite enrolling the majority of students, PUIs – associate's colleges in particular – received a disproportionately small fraction of S-STEM awards. Additionally, at the time of our search, Fiscal Year 2016 (FY16) awards had been made to institutions in only 50% of EPSCoR jurisdictions. By increasing the capacity of faculty members at PUIs in EPSCoR jurisdictions to successfully compete for funding, we can help improve the number and diversity of the institutions students S-STEM supports.

Analyses are not yet available on the status of all proposals submitted by workshop participants; however, we are using project summaries as one preliminary, indirect indicator of likely proposal quality. In this paper, we present the rubric and describe the results of the project summary evaluations as preliminary findings to address the question: To what degree and in what ways do participants' project summaries change from pre- to post-workshop? The results have implications for prospective PIs who are seeking guidance on strengthening areas of S-STEM proposals.

Introduction

The National Science Foundation Scholarships in Science, Technology, Engineering, and Mathematics (NSF S-STEM) program was created to provide support to develop the US workforce in several STEM disciplines. Funded through H1B Visa fees, the program provides scholarships for undergraduate and graduate students from low-income backgrounds who have demonstrated financial need and academic ability or potential to complete degrees in eligible STEM disciplines, and enter the STEM workforce or graduate schools afterwards. (Pearson Weatherton et al, 2016). In fiscal year 2016 (FY16), the S-STEM program began requiring the adoption/adaptation and study of evidence-based strategies to address challenges related to the "success, retention, transfer, academic/career pathways, and graduation" (NSF, 2016) of low-income students in STEM disciplines.

Based on 2013 data presented in *Science and Engineering Indicators 2016*, nearly 75% of all undergraduates (all majors, all income levels) enrolled in associate's colleges, baccalaureate colleges, and master's colleges and universities (NSB, 2016), which all fit within the definition of predominantly undergraduate institutions (PUIs). Associate's colleges enrolled 43% of undergraduates, which is the largest fraction among all institution types (NSB, 2016); many of these students are from low-income families. Recent data (2013-14) from The Carnegie Classification of Institutions of Higher Education shows 64% of all students (undergraduate and graduate) are enrolled in associate's colleges, baccalaureate colleges, master's colleges and universities, and tribal colleges (~32% in associate's colleges); 96% are enrolled in institutions with enrollment profiles that are exclusively, very high, high, or majority undergraduate (http://carnegieclassifications.iu.edu/downloads.php).

Despite enrolling the majority of students, PUIs have received a disproportionately low fraction of S-STEM award funds. A September 2016 search of NSF's award database (prior to receiving funding to support the workshop described in this paper) indicated at that time, 117 FY16 S-STEM awards had been made to 106 institutions totaling just under $132 million. (Note: Some of these included collaborative proposals, thus 117 does not represent the number of unique projects. Additionally, this does not include awards for workshops, conferences, or co-funding for projects in other programs). Table 1 shows the fraction of awards (number and dollar amount) by institution type. While 58% of awardees were one of four types of PUIs, those institutions received a smaller proportion of the funding (47%). Most notably, associate's colleges, which enrolled 43% of all undergraduates and 32% of all students, represented only 20% of awardees receiving just 10% of the funds.

Table 1. NSF S-STEM FY16 Awards as of September 2016

	FY16 S-STEM Awards (As of September 27, 2016)	
Category of Consideration	***% of Awardees (n=106)***	***% of Funding (n=$131.8M)***
Associate's Colleges	*20*	*10*
Baccalaureate Colleges	*8*	*5*
Baccalaureate/Associate's Colleges	*6*	*7*
Master's Colleges and Universities	*24*	*25*
Awardees in EPSCoR Jurisdictions	*19*	*16*

There are 28 Experimental Program to Stimulate Competitive Research (EPSCoR) jurisdictions (this includes 25 states, Guam, Puerto Rico, and the U.S. Virgin Islands). A total of 19 S-STEM awardees (17.9%) were located in EPSCoR jurisdictions and had received roughly $21 million (15.9%) of FY16 funding at the time of our search. Those awardees were distributed among half of the EPSCoR jurisdictions (50% of EPSCoR jurisdictions had not received S-STEM funding in FY16 at the time of our search). Overall, roughly 84% of FY16 S-STEM funding was awarded to 44% (22/50) states nationwide.

Capacity Building Workshop

The George R. Brown School of Engineering at Rice University received funding from NSF to support workshops designed to help faculty members at PUIs, with emphasis on those located in EPSCoR jurisdictions, prepare competitive proposals to the S-STEM program. For the proposal, we adopted the definition of PUIs set forth in NSF 14-579, "Facilitating Research at Primarily Undergraduate Institutions: Research in Undergraduate Institutions (RUI) and Research Opportunity Awards (ROA)":

> *PUIs are defined in terms of the nature of the institution, not solely on the basis of highest degree offered. Included by the definition are two- and four-year colleges, masters-level institutions, and smaller doctoral institutions that, institution-wide,*

have awarded 20 or fewer Ph.D./D.Sci. degrees in all NSF supported fields during the combined previous two academic years (NSF, 2014).

We used basic Carnegie Classifications to identify institution types. One limitation was the unavailability of information regarding the number of doctoral degrees awarded in NSF-supported fields. No data was available regarding declined submissions to the S-STEM program; however, two assumptions framed the development, implementation, and study of the impacts of the workshops: (1) faculty members from PUIs, particularly associate's colleges and those in EPSCoR jurisdictions, submit proposals at lower rates than their counterparts, and (2) proposals submitted by faculty members from PUIs, particularly associate's colleges and those in EPSCoR jurisdictions, are funded at lower rates than others. Large teaching loads, extensive engagement in service activities, and lack of institutional infrastructure and support have been identified as factors that limit faculty members' engagement in research activities at PUIs (Sharobeam and Howard, 2002). Moreover, S-STEM now requires knowledge generation, which may be limiting submissions from STEM faculty members at PUIs who are unsure about designing an educational research component for their projects.

The workshops focus on four areas we identified as being key to strong S-STEM proposals: (1) identifying institutional/program needs that align with S-STEM program goals, (2) adopting/adapting evidence-based strategies to address the identified needs, (3) generating knowledge from the study of the strategies implemented (and distinguishing this from evaluation), and (4) addressing STEM workforce development, with emphasis on effective academic-industry partnerships. Lunchtime talks focused on novel strategies for addressing NSF's merit review criteria – intellectual merit (the potential to advance knowledge) and broader impacts (the potential to benefit society) – and on considerations specific to students attending and/or transferring from two-year colleges. Participants attended the workshop in two-person teams – a principal investigator and a researcher with expertise in educational or similar areas of research as required by the S-STEM solicitation. During the workshop, the teams learned strategies for addressing each of the four key areas in their proposals and received real-time feedback on their ideas and their writings from workshop facilitators.

A total of 42 people (21 two-member teams) participated in the 2017 workshop. Of the 21 PI participants, 10 were at institutions located in EPSCoR jurisdictions, 15 were from PUIs, and 6 were from doctoral institutions that were chosen either because they are located in EPSCoR jurisdictions or because they are designated as Minority Serving Institutions (MSIs).

Data Collection and Analysis

As part of the workshop application, participants were required to submit a one-page project summary, formatted in accordance with NSF requirements. At the culmination of the workshop, participants were asked to revise and resubmit their project summaries. The project summaries were assigned random identifiers and were redacted so reviewers would not be able to determine the participants, their institutions, or other potentially identifying information. We developed a rubric for evaluating the content of each of the three sections of the project summary: overview, intellectual merit, and broader impacts. Each summary was scored by three or four reviewers using the rubric provided in Table 2. At the time of this writing, we have not yet analyzed data on the status of all proposals submitted by workshop participants; we are using project summaries as one preliminary, indirect indicator of likely proposal quality.

Table 2. Rubric for Evaluating S-STEM Project Summaries

Component	3 Points	2 Points	1 Point
Overview	A. Objectives are clearly stated and are aligned with stated institutional and/or program needs **and** S-STEM program goals. B. Both targeted majors and low-income students are specifically addressed.	A. Objectives are clearly stated and are aligned with either S-STEM program goals **or** institutional and/or program needs. B. Either targeted majors or low-income students are specifically addressed.	A. Objectives are not stated **or** objectives are stated but are aligned with **neither** S-STEM program goals **nor** institutional and/or program needs. B. Neither targeted majors nor low-income students are specifically addressed.
Intellectual Merit	A. Evidence-based strategies are described and appear to be well-aligned with institutional/program needs. B. Research questions are included. C. The potential for knowledge generation is strong.	A. Evidence-based strategies are described but do not appear to be well-aligned with institutional/program needs. B. Research questions are not included, but research hypotheses are. C. The potential for knowledge generation is questionable.	A. Evidence-based strategies are not described. B. Neither research questions nor hypotheses are included. C. The potential for knowledge generation is weak.
Broader Impacts	A. At least three areas of broader impacts are addressed, and more than one includes STEM workforce development or graduate school enrollment. B. Potential impacts are exceptional and far reaching (beyond the institution). C. The anticipated broader impacts are plausible and measurable.	A. At least two areas of broader impacts are addressed, and at least one includes STEM workforce development or graduate school enrollment. B. Potential impacts are typical and expected (across programs at the institution). C. The anticipated broader impacts are plausible, but not measurable.	A. Fewer than two areas of broader impacts are addressed, but none includes STEM workforce development or graduate school enrollment. B. Potential impacts are insignificant and limited to the program(s) involved. C. The anticipated broader impacts are not plausible or measurable.

Of the 21 original participants, 14 submitted post-workshop project summaries, thus our analyses are based on n=14 observations. We used a one-tailed t-test to perform matched pairs analyses on the mean scores in each section of the project summary to test the null hypothesis (H_0): there is no improvement in project summary scores post-workshop and the alternative hypothesis (H_a): there is an improvement in project summary scores post-workshop. Prior to performing the t-test, we examined skewness, kurtosis, and Shapiro-Wilk test parameters to verify our assumptions of normality were valid. Table 3 summarizes the Shapiro-Wilk test parameters. For scores in each section, the calculated p-values are greater than α=0.05, indicating, along with our other tests, we should retain the null hypothesis that the data are normally distributed.

Table 3. Shapiro-Wilk Test Parameters

	Overview	*Intellectual Merit*	*Broader Impacts*
SS	4.536210317	57.38492063	25.0952381
b	2.098666667	7.157466667	4.926083333
W	0.970943027	0.892731549	0.966968192
p-value	0.842	0.095	0.786

Table 4 summarizes the results of the matched pairs analyses. For the overview scores, we reject the null hypothesis ($p<0.05$, $t>1.771$); the results indicate statistically significant improvements in overview section scores for post-workshop project summaries when compared to those submitted pre-workshop. For both the intellectual merit and broader impacts section scores ($p>0.05$, $t<1.771$), we fail to reject the null hypothesis.

Table 4. One-Tailed t-Test Parameters

	Overview	*Intellectual Merit*	*Broader Impacts*
Mean	5.476190476	4.80952381	5.976190476
Variance	0.43956044	2.884004884	2.811355311
Observations	14	14	14
df	13	13	13
t Statistic	3.506410594	-0.954047569	1.378571206
P(T≤t)	0.001933115	0.178731937	0.095644275
t Critical	1.770933396	1.770933396	1.770933396

Conclusion

Though preliminary, our results indicate that after the workshop, participants made stronger connections between their institutional/program needs and S-STEM program goals and more clearly addressed the targeted student population(s) in their project summaries. By contrast, they did not improve in their abilities to align evidence-based strategies with institutional/program needs and to present research questions that showed potential for knowledge generation or to identify multiple areas of far-reaching, plausible, and measurable broader impacts, including those related to STEM workforce development and graduate school placement.

One of the limitations of our analysis is that the post-workshop summaries were collected immediately following the workshop, and thus are not necessarily reflective of the summaries that were actually submitted with the proposal. We believe after participants returned to their institutions and used the knowledge gained from the workshop to refine their proposals, their project summaries likely changed to better reflect the proposal's contents and the application of that knowledge. At the time of this writing, we are roughly one year past the 2017 S-STEM due date, and our external evaluator is in the process of analyzing one-year follow-up data from the first cohort of participants. This includes project summaries as submitted to NSF with their proposals, as well as proposal status (not submitted, awarded, declined, in negotiation), and other data to help gauge the impact of the workshop.

The most competitive proposals will respond fully to requirements specified in the solicitation and/or the Proposal & Award Policy and Procedures Guide (PAPPG) that are in effect at the time of submission. Below we summarize a few key recommendations for improving S-STEM proposals based on the program solicitation (NSF, 2016) and our experience with the workshop.

- Make sure the project team meets S-STEM requirements. At a minimum, three people are required. Note that while an individual may have expertise and/or responsibilities in more than one area, he/she should only fulfill one role for this project.
    - Faculty Member. S-STEM requires the PI team to include a faculty member who is currently teaching in one of the eligible S-STEM disciplines. For Track 1 and Track 2 proposals, the PI must meet this requirement. The faculty member is considered the person in closest contact with the students, and most in touch with their academic, professional, and other needs.
    - Educational Researcher. All S-STEM proposals are required to include a project team member who is an educational, discipline-based educational, social/behavioral science, or institutional researcher. This team member's role is to make sure the project is grounded in the literature and to develop and implement a research study (including research questions) to generate knowledge on success of low-income students. A strong knowledge generation component strengthens the intellectual merit of the proposal. For Type 3 proposals, the educational (or similar) researcher may be the PI; however, the other two team members are still required.
    - STEM Administrator. The administrator is a person who can help make connections needed for the project's success. The exact title/role of the administrator will be project-dependent. For a single-discipline S-STEM proposal, the STEM administrator might be the department chair. For college/school-wide proposals (e.g., College of Engineering), a dean or associate dean might be most appropriate. For others, a provost or vice provost might be appropriate. One thing is to consider is who can best make the connections needed to get the project off the ground (e.g., get data from financial aid and other offices, make sure S-STEM cohorts are included in certain established programs/activities, etc.). Another consideration is who has the authority to institutionalize, or lead the institutionalization, of successful elements of the project.
- Before starting to write the proposal, identify a qualified external evaluator. By S-STEM's definition (at the time of this writing), this person must be external to the project team (i.e., not a Co-PI or other Senior Personnel), but not necessarily external to the institution. He/she can develop a logic model to help with project planning and evaluation and should be the person who writes the assessment and evaluation plan for the proposal, including specific, measurable outcomes.
- Make strong connections between institutional and program needs and S-STEM program goals. This not only strengthens the proposal because of responsiveness to the solicitation; it can also potentially help with securing institutional commitment for sustaining successful project elements beyond the funding period. Use data to show the needs, including financial needs.

- Think creatively about broader impacts. Every proposal submitted will (or should) describe impacts on underrepresented populations, namely students from low-income backgrounds (this is the population of focus for S-STEM projects). Think about what will set this project apart from the rest. Look at examples of areas of broader impacts listed with NSF's merit review criteria in the solicitation and/or the PAPPG. Select relevant areas of impact and elaborate on how the project will lead to those impacts. In particular, be sure to address workforce-related impacts, as they align strongly with S-STEM program goals. In addition to summarizing them under the "Broader Impacts" heading in the project description, be sure to integrate them throughout the proposal and have the evaluator include them in the assessment and evaluation plan.

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