Developing STEM Educational Grant Proposals: Best Practices

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Abstract

Many programs at the National Science Foundation (NSF), and other funding agencies, have a goal of the improvement of science, technology, engineering, and mathematics (STEM) education. Funding opportunities exist for laboratory development and curricula reform in support of improvement in student learning and STEM educational pedagogy. Understanding all facets of the grant proposal process, from inception through proposal review and, ideally, to grant awarding is critical in the development of nationally competitive grant proposals. With many components required for a successful grant proposal, it is important for a potential grantee to develop a set of best practices when undertaking grant proposal writing efforts.

The author of this paper has written a successful NSF Adaptation and Implementation grant proposal [1] entitled "An Integrated Internet-Accessible Embedded Systems Laboratory" and a successful NSF Department Level Reform grant proposal [2] entitled "Developing a Modern Computer Engineering Curriculum Focusing on Embedded Systems." The goal of this paper is to suggest best practices for proposals for people considering writing similar grant proposals. Considerations include properly addressing program solicitation requirements, proposal organization, proposal readability, and related issues.

Introduction

NSF supports STEM education through many programs [3-6]. These programs span multiple directorates and divisions including, most notably, the Division of Undergraduate Education (DUE). Programs currently supported in DUE fall under the categories of Curriculum, Laboratory & Instructional Development and Workforce Development. The well known Course, Curriculum, and Laboratory Improvement (CCLI) program one example. With the numerous programs and solicitations supported, many opportunities for STEM educational grant proposals are available.

Other, often cross directorate, STEM programs include Grants for the Department-Level Reform of Undergraduate Engineering Education (DLR), Centers for Learning and Teaching (CLT), Research Experiences for Undergraduates (REU). Many of these programs are a part of the Division of Engineering Education and Centers (EEC). In developing a STEM proposal, selecting the correct program, and the correct solicitation, is the first step in the successful proposal process. A proposal that does not fit the program/solicitation, however well conceived, may stand little chance of funding. A well thought out plan that not only addresses the correct program, and the correct solicitation, but that also plans for future related proposal development to other programs is more likely to be well received.

Proposal Inception

Most educators do not need to think long about the need for STEM education improvements. Whether the need is in curriculum reform, laboratory improvement or dissemination of already implemented programs, the benefits of seeking educational funding are usually apparent. Student feedback, an ABET review, or a simple curriculum review are often all that is necessary to expose areas that need improvement and that are ripe for STEM educational grant proposal efforts. Many educators may simply begin the process by reading a solicitation and fitting a proposal to the solicitation. Unfortunately, this is not necessarily the best approach to developing a successful proposal. A self assessment of a program or educational goal is a much better starting point. Both our educational grant proposals stemmed from an initial self study of the computer engineering program at The University of Alabama.

Successful STEM proposals should address an actual need in a given program, but although necessary, this is not a sufficient condition for proposal funding. Rather, the successful proposal should address a specific program need where the results of carry out the proposed work should extend beyond a single program or institution. Proposers should spend a good amount of time considering how the proposed effort might be adopted by other programs or even other disciplines. This philosophy is captured in the “broader impact” requirement in NSF proposals. Most programs share fundamentally similar needs. An educational literature review or participation in a national education-oriented conference should provide insight to developing a proposal that addresses not only local, but also national needs.

Early in the proposal inception stage is an ideal time to contact NSF program officers to get early feedback about the appropriateness of a particular idea. This communication is not only welcomed, but it is particularly encouraged on the part of NSF. Also, a review of previously funded NSF proposal abstracts, via FastLane, is useful in terms of seeing what types of STEM efforts have been previously funded. This review may also provide contact information for other grantees that may be willing to share their proposal development experiences.

Proposal Preparation

Here we list some, hopefully obvious, but often overlooked issues in the proposal preparation process. This is not intended to be an all inclusive list, but rather a compilation of some of the more important facets of the proposal preparation process.

1. *Project goals* – The project goals must be clearly articulated and consistent with the solicitation objectives. These goals must include rational development, evaluation and assessment. Important ideas must be clearly delineated in the proposal. NSF program directors and review panel members will not “hunt through a proposal” for information.

2. *Time* – The successful proposal is well planned and thoroughly reviewed before submission. A minimum of three months is necessary to develop a competitive proposal from scratch. Five to six months is a more reasonable expectation, especially if multiple investigators from multiple institutions are involved. Our proposal efforts are team

oriented with each investigator assuming responsibility for particular components of the proposal with the principal investigator assuming overall responsibilities. In our computer engineering faculty, these responsibilities rotate among faculty as interest demands. We normally have two meetings pre week including faculty involved in the proposal. One focuses on the implementation of current grants and the other focuses on pending proposals and future education/research directions.

3. *Address program solicitation* – Too often, proposers fail to address one or more of the criteria presented in the program solicitation. Wording in the solicitation such as "*the proposal must ….*" or "*strong consideration will be given to …*" should receive special attention. NSF provides additional guidelines/suggestions for potential proposers in advice or supplemental information documents [7, 8]. Browsing the NSF awards database is a good beginning to determine the types of education proposals NSF typically funds. This may also lead to relationships with other investigators with similar interests.

4. *Additional review criteria* – "Intellectual Merit" and "Broader Impacts" are important in the proposal review process. NSF DUE provides additional review considerations relevant to these two items in the various program solicitations. You should make sure your proposal addresses each of these considerations.

5. *Evaluation plan* – Most successful STEM proposals must include a detailed evaluation plan. Solicit external evaluators that will provide feedback on your project. One of the best choices would be nationally known educational scholars that would also have a truly vested interest in the results of your project. For our current CCLI grant, we formed an external evaluation team consisting of faculty at prestigious universities and local industry that employs our graduates.

6. *Broader impact* – The successful proposal should address a global versus a local problem. Demonstrating how a particular result of the project can and will have a broad, national impact is critical. This particular investigator labored for years under the disillusion that the NSF programs existed to solve problems at local institutions.

7. *Institutional and collaborator support* – Successful proposals show institutional and other collaborator buy-in in the form of support letters from department, college and institutional administration. Letters of support from participating members (i.e. advisory panel, industrial participants, etc) are also important. We solicited collaborator support from a number of prestigious universities and from industry participants that had an active interest in our program.

8. *Reasonable budget* – Budget items should be consistent with the project goals. Support should be sufficient for the intended work. Do not "promise the world" for a single dollar. A realistic budget with appropriate investigator support, equipment, travel, and other necessary expenditures will be well received. A budget that is skewed and that does not seem to support the proposed effort will be questioned. For our CCLI proposal, the NSF-funded budget breakdown was approximately 35% investigator salaries, 30% equipment, 10% travel, 5% undergraduate assistants and the remainder in indirect costs.

For the department level reform planning grant, the NSF-funded budget breakdown was approximately 40% investigator salaries, 25% graduate student stipend and tuition grant, 8% travel, 2% materials and supplies and the remainder in indirect costs.

9. *Dissemination of results* – The proposal should include appropriate channels for the dissemination of project results. A proactive and aggressive plan is necessary. The plan might include conference and journal publications, faculty workshops, electronic media, etc. A plan for evaluating the effectiveness of the dissemination is also useful. We have begun this effort with conference publications, organizing special sessions and workshops at conferences and will conclude with journal dissemination.

10. *Plan for the future* – Relating the proposal to "*Results from prior NSF support*" is important in that it establishes the credentials of the proposer for carrying out the effort. However, showing a well organized plan for future development, either to another related program or beyond NSF support illustrates the importance of the project to the proposer and gives a sense of continuity. Our current plan is for the submission of a department level reform implementation proposal, associated research experiences for undergraduates proposals, and eventually an engineering education center proposal.

Proposal Organization

The project summary is normally the first thing read by review panel members and a good initial impression must be made with a strong summary. The summary should describe the problem at hand, your proposed solution to the problem and why it is of importance beyond a local scope. Objectives and outcomes should be clearly summarized.

The proposal organization should reflect the suggested sections and length noted in the program solicitation. Consideration should be given to the limited time panel reviewers may have to review the proposal. Also, panel reviewers may be experienced or novice and may or may not be expert within the proposals technical area. A proposal that is well organized and easy to read will, in general, be better received by a review panel. Use of bulleted or list structured text for describing the major points of the proposal simplifies the review process and make for a well received proposal. Concise statements that effectively demonstrate the who, what, where, and why components of the proposal are key to a successful proposal.

Results from previous work should be emphasized and tied to the plan presented in the proposal. This is especially true if the previous work was particularly successful (*i.e.* well disseminated, referenced in the literature, adopted by other universities, etc.). Additionally, the proposal must demonstrate the investigator's knowledge of educational scholarship relevant to the project.

Planning for Future Efforts

Many reviewers may look at a proposal to see if it fits within a larger plan. This seems to be especially true for smaller planning grants and when the proposer specifically references future efforts. Since many NSF programs overlap, it is reasonable to expect that a successful smaller grant (such as a CCLI grant) may lead to larger, department level reform grants and even to the very large-scale centers to teaching proposals. Coordinating grant efforts of a period of years can be fruitful if the problem is of national significance and success is demonstrated in each separate effort. All funding agencies like success stories. These are often called "*nuggets*".

Also, do not neglect to consider how a STEM educational grant may lead to research grant development. Educational grants have the ability to stimulate growth in infrastructure. One example would be an undergraduate who participates in or is a beneficiary of a STEM effort and is subsequently motivated to pursue graduate work in the same area. Finally, acquaint yourself with the NSF review process. This can be accomplished, in part, by attending NSF grant-oriented conferences. However, the best mechanism for learning about the review process is to serve on a review panel. No other experience will educate you about the dynamics of review panels and program directors as much. And, NSF program directors are always seeking qualified reviewers.

Conclusions

There is certainly no one right way to right a successful STEM proposal. Indeed, differing divisions within NSF have different requirements and there is no single general template that will lead to a successful proposal. However, there are certainly many ways to write an unsuccessful proposal. Perhaps the best practice, as we all might expect, is to research the program requirements, choose a problem of national significance for which you have a good idea, and make sure your proposal meets or exceeds all program expectations. Finally, if your grant proposal is not successful, take the reviewers' comments to heart and improve and resubmit.

References

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