

# NSF Proposal Preparation: The View of an Ex-Program Officer

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This article is the third in an occasional series intended for graduate students and young mathematicians. The series is coordinated by *Notices* Associate Editor Lisa Traynor.

The task of obtaining external funding to support research has become a critical point in the career of the young mathematician. Obtaining funding can have a profound effect on the recipient's career as the imprimatur of external funding provides in the eyes of many a confirmation of the importance of the recipient's research activity. While the reality is that the research proposals that are funded tend to be the ones that are excellent, there are very many excellent research proposals that are not funded. This note is intended to provide some insight into the process of funding at the National Science Foundation (NSF) based on my two years' experience as a program officer in the Division of Mathematical Sciences. While the advice I give is directed to the applicant for NSF funding, the basic principles are applicable to funding proposals to any external funding source.

It is important to recognize that the agenda for the process is established by the National Science Foundation. This agenda is not ordinarily established by mathematicians but is instead the consequence of intellectual, political, and cultural concerns of the government. The immediate consequence of this is that the direction and employment of funds as well as the criteria for awarding them is established in order to satisfy the NSF's own purposes rather than an agenda established by the mathematical community. It is important to be alert to the agenda of the NSF and to understand its needs in the process of supporting mathematics. The mission statement of the NSF calls for it "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...". Although the objectives of the mission statement are not usually explicitly addressed in the proposal submission, it may be useful to contemplate how the proposal addresses these issues—most particularly for mathematics—in promoting the progress of science.

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Applications to the NSF for funding are made in response to a Program Solicitation. That solicitation might be the program's description of the area program; it might be an explicit solicitation for proposals for the particular program; it might take the form of a "Dear Colleague letter". A prospective applicant should examine the range of solicitations to find the solicitation that best fits the proposed work. A typical solicitation contains a detailed description of the program, the method by which the proposals are to be evaluated, criteria by which proposals are to be evaluated, budgetary guidelines, and contact information for program officials. **Proposals sent in response to a solicitation need to be responsive to the solicitation.** In particular the solicitation should be carefully and fully read and the issues that are raised by the solicitation need to be fully addressed in explicit detail by the proposal.

The statement in bold of the previous paragraph may seem to follow immediately from the definitions. Observation would seem to indicate however that it is not obvious. Every solicitation is an effort to direct funding to accomplish or encourage activity that the foundation views as important to the furthering of the NSF's agenda. Funding success depends on meeting the criteria specified in the solicitation, so proposals should explicitly address those criteria. Having identified a potential source of funding, the next step is to **read the guides for the format and submission of proposals and to follow the criteria established for the program.** Agencies have established guides for proposals. The NSF Grant Proposal Guide covers general procedures for grant submission to NSF ([http://www.nsf.gov/pubs/gpg/nsf04\\_23/](http://www.nsf.gov/pubs/gpg/nsf04_23/)). It is revised periodically. Individual solicitations at NSF will indicate the procedures to be followed for that solicitation and deviations from the general procedures of the Grant Proposal Guide.

Some programs permit the submission of a proposal at any time. Others restrict the submission to certain windows. This can be expressed in two principal ways. One is an explicit time window with (sometimes) an opening date and a deadline for proposal submission. The other is a target date for submission. These windows for proposals are dictated by the beginning of budget years, staff workload requirements, as well as other factors. Proposals for funding should be sent

within the proposal window. This is absolutely necessary in the presence of deadlines. **Failure to adhere to the deadlines for proposal submission may lead to a proposal being returned without being reviewed.** On the other hand, target dates are indicators to the eligible that proposals should be sent in proximity to that time. Target dates are principally used by area programs at NSF, but not all such programs have target dates rather than deadlines. The use of target dates allows for more efficient budgetary planning and staff resource allocation. Proposals that arrive after the target date will be considered but proposals that are submitted long after the target date has passed may find that, by the time they are reviewed, the budget for the program has already been allocated.

Some programs have a pre-proposal phase. The pre-proposal may be required or optional. The character of such a pre-proposal can vary from a letter of intent to submit a proposal to a full scale mini-proposal. There are usually managerial requirements that necessitate a pre-proposal phase. The pre-proposal phase may be used to limit the number of proposals to those most likely to be successful, or the pre-proposal phase may be used only to determine the number and composition of the reviewing panels. The fact that the purpose of the pre-proposal phase is proposal management does not mean it is not important. The pre-proposal may undergo as complete a review process as any full proposal.

The NSF has established two review criteria that are used in virtually all proposal evaluations. The first review criterion is

### **What Is the Intellectual Merit of the Proposed Activity?**

How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

In short, the first criterion is to evaluate the proposal based on the intellectual merit. Consequent to this review criterion: **The proposal must address the problem of what goals are to be accomplished and what the impact of attainment of those goals would mean.** While it might appear that this requirement is self-evident the failure to meet this requirement is the leading cause for proposals to fail. There are two parts to this requirement. The first is that the proposal must relate what goals are to be accomplished. If the proposal is in response to a solicitation those goals must match the agenda set forth by the solicita-

tion. In all cases, the stated goals should match the objectives of the funding agency. The goals should be presented in a manner that would permit the decision makers in the funding process (reviewing panel, study session, program manager) to understand what the objectives of the proposal are.

Furthermore it is extremely important to tell the decision makers why they should fund the proposal. Each proposal asks someone to invest limited resources into a particular project. The motivation for doing so varies amongst funding organizations but every funding entity looks to justify their investment. If the proposer is unable to articulate a reason for investment of funds in a particular project, there is little likelihood that the decision makers will find a reason to invest in the project.

The proposer should take it for granted that all (or virtually all) of the proposals that are submitted to the program to which they are applying are in some very real sense excellent. The competition for funding is amongst these excellent proposals. In this competition, the ones that stand out are those that provide a strong and compelling case in response to the funding announcement to the question as to why they should be funded.

This requires explaining in some considerable detail to an informed but not necessarily specialist mathematician reader what real impact the proposed research will have and what insight is being provided to attack the problem. It is however not sufficient to merely explain the mathematical content of the proposal. What is required is to place the mathematics that is being proposed in a context that indicates its importance in mathematics or in a broader context. This is the answer to the question: Why would one wish to know the consequences of the proposal's research?

Some careful consideration should be given to the preparation and delivery of this material in the proposal. A typical failing of an excellent but unfunded proposal is a dismissive attitude towards the context of the proposal. The NSF funds all types of research in the mathematical sciences, from foundational issues in logic to the modeling of ice in the Antarctic. The issue is not the type of research that is being proposed; the issue is why the research being proposed is important. This requires more than a one-sentence comment that says that the topic is connected to research in another field and hence is important. If the proposer of the research is not able to put the importance of the work in context, is not able to explain why the work is an important element in the "progress of science" or important in advancing "the national health, prosperity, and welfare" or in "securing the national defense", then why is the work important enough to rise to the level where it should be funded over other proposals that do make that argument?

One also needs to establish why the proposer has the ability to perform the work that is being proposed. It is not sufficient to propose the solution of one of the millennium problems; it is necessary to provide a reasonably educated mathematical reviewer with a clear indication of the new idea that is to be exploited in the project. This does not require the presentation of a proof but does require a detailed exploration of the ideas and difficulties in obtaining the goals of the proposed work.

To summarize, there is a key but sometimes forgotten distinction between excellent proposals and excellent proposals that get funded: The latter provide, by exploring the intellectual consequences of the proposed work, compelling reasons why the work should be funded.

The second review criterion is:

### **What Are the Broader Impacts of the Proposed Activity?**

How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

The NSF in the second review criterion also demands that the proposal explicitly address the broader impact of the proposed work.

In short, the second criterion at NSF asks how this proposal will aid in the furtherance of the mission, objectives, or goals of the National Science Foundation. This criterion was written to make it clear that proposals in which the NSF is providing funding address not only scientific research objectives but also the broader national needs whose accomplishment is charged to the foundation.

The proposer might wish to look at the sample broader impacts provided by the NSF at <http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf>. These are not however to be regarded without consideration of what are the actual accomplishments to be obtained by the proposed work. What outcomes can be seen as emanating from the proposed award? Are graduate students, undergraduate students, K-12 students (future scientific workforce) being supported in the proposal? Is the scientific education infrastructure benefiting from the award—in what manner is this accomplished? Will the award have benefit to the crucial problem of addressing mathematics and science in secondary education?

It is a mistake to think that the proposal should address all of these issues or that these comments or the listing at the above website is an exhaustive list of what is sought. What is required by the criterion is to address the question of how the individual proposal addresses the broad national interest that the NSF represents.

One should also consider the process in which the proposal will be reviewed. At NSF, depending on the program, the proposal will be reviewed by a combination of panels and/or individual non-interacting (ad hoc) reviewers. Each of these processes has its own peculiar aspects that may dictate differing approaches by the investigator in the presentation of the proposed work. Each of these review processes will present particular challenges to the aspiring investigator.

Panel reviewers are drawn from established researchers in the general field of the proposal. They are less likely to have direct knowledge of a particular subfield than individual non-interacting reviewers. The proposal will be sent to three or more of the panelists to review for the panel. These reviewers need not be experts in the particular subfield of the proposal. In fact it is highly likely that at least one of the panel reviewers will be deliberately chosen outside the particular subfield of the proposal. This may necessitate writing more material to describe the setting of the proposed research and require considerably more detail on the importance of the intellectual merit of the proposal to give context to the proposal to the reviewers. The panel members each will review considerably more proposals than are reviewed by typical non-interacting individual reviewers and therefore tend to be in a better position to establish the relative placement of proposals. Panel reviewers have a considerable amount of reading to do, so proposal-writers will want to establish early and often in the proposal the value of their proposed work. The panel reviewers will meet and discuss each proposal individually. The discussion is led by the panelists that reviewed the proposal prior to the panel's meeting.

Individuals who review the proposals "ad hoc" or reviewers from within the NSF are usually in a better position to understand the requirements of the funding entity but are less likely to have an understanding of the intrinsic value of a proposal.

Beyond the requirement of addressing the issues raised by the required format of the proposal there is one central requirement that must be addressed by every submission. How will this work benefit the mission of NSF? Congress exercises considerable oversight of federal programs, and it is routine for senior executives of federal agencies to be called to explain funding decisions—even at the level of funding decisions for individual proposals. This was part of the motivation for the recent NSF decision to require that proposals submitted to the

NSF explicitly address two criteria for funding decisions. The second criterion examines the broader impact of the proposal. Simply put this asks for the consequences that funding the proposal will have on the broader community of science. These will vary from proposal to proposal but might include training of students in the techniques of the area or applications of the work to questions in another area of science. Mission oriented agencies such as the Office of Naval Research express this in a more direct manner: asking that proposals explain “Potential contributions of the effort to the agency’s specific mission.” The requirement is the same, however, across all funding agencies: Explain why giving the money to this project furthers the aims of the funding entity.

It is very important to remember one of the first statements of this article: that it is important to recognize that the agenda for the funding process is established by the entity that is doing the funding. The agenda of the entity will be reflected in the funding criteria; proposals need to address the issues raised by the criteria.

The budget is simultaneously the simplest and the most complex part of any proposal. The simple solution to the question of budgeting is: **The budget should be sufficient to attain all of the objectives of the proposal.** There is an additional caveat. **The amount requested should conform to the pre-established award sizes, or be comparable to program awards of similar complexity.** Some agencies and some programs provide pre-established award sizes. These provide guidance as to the level of complexity expected of an award. Many funding entities provide examples of previously funded awards to provide budgetary guidance.

It is most important to note that the funds requested should be sufficient to fulfill the objectives of the proposal. Proposals are not funded because they request “just a small amount of funds”. Proposals are funded because the objectives of the proposal meet the requirements of the funding entity. Some agencies restrict application of funds to redirect the investigators’ activity from one aspect of their job to work on the project—others encourage such buyout. The proposer/investigator needs to work with the sponsored program officer at his or her eligible institution to design a budget that conforms to the requirements of the funding entity.

It is important to find mechanisms to support students with external funding. This is an important issue for our profession and in addressing the national need for a well-trained scientific workforce. When grants support undergraduates, they encourage these and other undergraduates to see mathematics as a viable career choice. Funds that support graduate students, and particularly funds that support graduate students directly in

their objective to obtain a degree, offer an opportunity to sharply reduce the time to obtain a degree. They enable a more focused direction of the students’ work on their thesis. Graduate student support can also offer a means to increase the success in obtaining the scientific goals of the proposal. The presence of support for graduate students on a proposal also has the potential to indirectly broaden the objectives of the proposal by addressing the issue of training a scientific workforce for future requirements of the United States. Different funding entities and programs have different requirements for the support of students. It is important, however, to be able to give an indication of the student’s identity at the time of funding.

One should not neglect the potential for funding teachers and K-12 students. The direct scientific impact of funding the participation of these groups may not be significant; however, there are significant indirect benefits of encouraging and strengthening mathematical activity at these early levels of education.

The budget returns our attention to the institution, as with the possible exception of some fellowships, individuals do not receive awards. Individuals do not in general have the ability to handle the financial reporting requirements imposed by governments and foundations. Awards are made to institutions. Budgets reflect this reality. Federal relations with educational institutions are governed by Office of Management and Budget Circular A-21 Principals for determining costs applicable to grants, contracts, and other agreements with educational institutions (<http://www.whitehouse.gov/omb/circulars/a021/a021.html>). The provisions of the circular require that a cognizant federal agency (usually the Office of Cost Allocation of the Program Support Center of the Department of Health and Human Services) enter into an agreement to provide for “costs that are incurred for common or joint objectives and, therefore, cannot be identified readily and specifically with a particular sponsored project, an instructional activity, or any other institutional activity.” These are known as Facilities and Administration Costs (F&A). These are usually computed as a percentage of the Modified Total Direct Costs. The percentage of the Modified Total Direct Costs allocated to F&A depends on the nature and location of the activities supported. This percentage is negotiated between the government and the institution and may change as institutional costs are reevaluated. The modification of the direct costs eliminates certain costs as direct costs for calculation of the F&A as specified in the agreement between the institution and the government. For example, tuition costs for supported students and costs of conference and workshop participants are not included in the Modified

Total Direct Costs. Proposers should also be alert that some proposals specifically exclude certain participant support costs from the total direct costs or provide for an alternative computation of the F&A.

At some point in the award process, proposers might be asked to reduce the requested budget. A significant reduction of a budget submitted to a federal agency will trigger a requirement to reduce the scope of the project. This means that the agency acknowledges that the funds will not be sufficient to obtain all the objectives that were established in the proposal and calls upon the investigators to reduce the level of activity of the project and the corresponding objectives to be obtained. The reduction in scope of the project should be correlated with the change in the budget.

Receipt of an award does not end the responsibility of the investigator. There is an obligation to spend the funds in accord with the objectives of the project. One might review the semiannual reports to Congress of the Inspector General of NSF (<http://www.nsf.gov/oig/pubs.jsp>) to provide an indication of the degree of seriousness the federal government takes in auditing its expenditures. There is also an obligation to fulfill the conditions upon which the award has been made, from promoting seat belt use to periodic reporting on the accomplishments of the project. One should remember that the obligation remains upon the funding entity, the program, and the program's employees to justify the expenditure. In particular, programs need success stories. These provide programs with the opportunity to increase base funding levels while programs unable to document successful accomplishment of their goals may face below-average increases or even decrease of base funding levels.

Having funding from a program or funding entity does not preclude seeking additional funding from the same or different programs or entities to support other projects. (Note that seeking funding for the same project would be unethical and potentially criminal.) One should not become dependent on a single funding source to support our students or our objectives.

A wise man said to me: "Don't ask me how to obtain funding; rather present to me a good idea and a source will be found to fund it." Ultimately the test of whether a proposal will be funded is if the idea presented in the proposal is found meritorious in the marketplace of ideas. It is incumbent upon us as mathematicians to provide evidence that support of our discipline is essential to the development of science. Exploring and finding vehicles for support of mathematics and mathematics students is essential in that quest.

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