

HONING YOUR PROPOSAL WRITING SKILLS

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To young faculty starting their academic careers, that first big grant is very important. To the more senior faculty, that next big grant may be the lifeblood of some graduate students. And a key source of these grants are federal funding agencies such as the National Science Foundation. NSF specializes in the funding of fundamental research and education. So it's a good place to go for support for research that can lead to masters and PhD theses. But NSF is highly competitive, and winning an NSF award can be quite challenging.

On the one hand, there are many courses and references available to help faculty learn how to write a good proposal. And surely they have good tips. But, on the other hand, few get to the core of the problem: why do so many proposals, centered around basically good ideas, get such poor ratings? Having been involved in the review of several thousand proposals, I have some observations to report. Typical problems with proposals include:

1. Failure to follow submission guidelines—NSF, for example, will return without review proposals that do not follow guidelines published in their Grant Proposal Guide. If you're going to take a month or two of your life to write a proposal, I strongly advise that you take an hour to read the GPG. If you are submitting to another agency, read their proposal guidelines carefully.
2. Use of small fonts and illegible materials—It makes no sense whatever to submit a proposal in a format that cannot be read. Yet people do it. As many as half the proposals received at NSF include totally illegible materials, particularly figures and tables, where fonts have been compressed to micron sized grey blobs. I strongly recommend only approved 12-point fonts and nothing smaller, including tables and figures. Smaller is not readable, and it only aggravates the reviewers. Use smaller fonts only if you want a lower rating.
3. Misspellings and poor grammar are commonplace—I find that about one in thirty proposals (give or take) has a misspelling in the title. This is a degree of sloppiness that does not impress reviewers. Bad grammar simply makes the proposal difficult to read. NSF does not use grammar as a review criterion, but I'm here to tell you that it counts. It really doesn't matter how good your idea is if the reviewers can't understand it.

These things are so obvious that you may be wondering why I bother to note them. Well, I note them because upwards of two-thirds of the proposals I see have substantial problems in at least one of these three areas. But these aren't the worst thing people do to hurt their chances. The biggest problem I am seeing is that fewer than one in ten investigators frames their research in a way that is to their advantage.

It should be totally obvious that the most important thing a reviewer wants to know when he or she picks up a proposal is what it's about. Ergo, for NSF, the first sentence of paragraph one, page one should begin, "The research objective of this proposal is..." In my experience, any other sentence used to start the proposal results in a lower rating. Every inch from the top of the first page that I have to go down in the proposal to find this sentence, in my experience, lowers the rating by

about one percentage point. At nine inches of text per page, the chance of an award goes to zero if this statement doesn't appear before page 12, or if it doesn't appear at all (and that's not all that infrequent).

The second thing that should be obvious is, given that NSF funds fundamental research, the research objective of the proposed project should be research. There are many words that, to reviewers, mean "not research." These include "develop," "design," "optimize," "control," "manage," and so on. If your statement of your research objective includes one of these words, for example, "The research objective of this proposal is to develop....," you have just told the reviewers that your objective is not research, and your rating will be lower. Count on it. This is how your peers think. Indeed, it is exactly how you will react when you review your colleagues proposals.

So, what is the right way to frame an engineering research proposal objective? First, you have to understand what is research. I define research as the process of finding out something that we (society) don't already know (this excludes library research). Note that research is a process, and it is exactly this process that your proposal is about. The objective of your proposal is precisely what you intend to find out that we don't already know.

Of course NSF doesn't fund all kinds of research, it funds scientific research. Scientific research has three properties that may distinguish it from other forms of research. First, it is methodical. That is, in advance of doing the project, you can lay out a methodology by which you will conduct your research, and that methodology leads knowledgeable reviewers to be able to assess the likelihood of success at achieving your stated objective. Second, it is repeatable. That is to say that, if reasonably competent persons repeat your methodology reasonably well in disparate locations at different times, they will get essentially the same results. Third, it is verifiable. You can show that the results you have obtained are the results you claim.

To illustrate this last point, consider my project to be proving the existence of ghosts. My methodology is to take my camera with me into the elevator late at night. I push the basement button. When the door opens, I see the ghost, and take its picture with my camera. When the ghost's image does not appear in the picture, I have proven that it was a ghost. Well, sorry to tell you, I have seen proposals that read pretty much like this.

Some scientists are taught how to frame research projects. Few engineers are, even PhD engineers. So let's first try to understand the difference between science research and engineering research. To me, the difference is quite clear. The scientist seeks to understand nature at its core, to get to the fundamental essence. To do this, the scientist typically strips away extraneous effects and dives deeply into a very narrow element of nature. And from this look comes what we refer to as the laws of nature: energy and mass are the same thing, for every action there is an equal and opposite reaction, and so on. There are lots of laws of nature, and they apply everywhere all the time.

Engineers live with the laws of nature. They have no choice. Their goal is to design things that work within what nature allows. To do this, they have to be able to predict the behavior of systems. So a big question for engineers is, how do we understand and predict the behavior of systems in which all the laws of nature apply everywhere all the time. This is an issue of integration, and it is every bit as difficult as finding the laws in the first place. To account for all the laws of nature everywhere all the time is an impossible task. So the engineer must find ways of determining which laws are important and which can be neglected, and how to approximate those laws that are important over space and time.

Engineers do more than merely predict the future. They make decisions based in part on their

predictions in the knowledge that their predictions cannot be both precise and certain. Understanding and applying the mathematics of this is also important. This includes the application of probability theory, decision theory, game theory, optimization, control theory, and other such mathematics in the engineering decision making context. This also is a legitimate area of research for engineering.

Understanding what comprises engineering research, you can begin to formulate your research project. I know of only four ways to state a research objective. If you can think of another, please let me know. The four I know are these:

1. “The research objective of this proposal is to test the hypothesis H.”
2. “The research objective of this proposal is to measure parameter P with accuracy A.”
3. “The research objective of this proposal is to prove the conjecture C.”
4. “The research objective of this proposal is to apply method M from disciplinary area D to solve problem P in disciplinary area E.” This research integrates knowledge from one disciplinary area into another. To do this often involves the resolution of inconsistencies across the disciplines.

The very statement of your research objective should lead you directly to your methodology. If it does not, you don't have a clear statement of research objective. I frequently hear statements that are essentially, “The research objective of my proposal is to learn how to make anti-gravity boots.” The problem with this statement is that it leaves one clueless as to what direction the research might take. It provides no insight whatever regarding the methodology.

Not only will a clear, crisp statement of your research objective help you write a better research approach section in your proposal, it will, by itself, raise your rating. Put your research objective right up top in your proposal, and remember the three tips I started with, and you are a long way toward writing a better proposal that will review well.

In the end, you have to remember, you are writing a proposal. A proposal is not a technical paper, in which you take the first three pages for background and credits to those who have come before you. Nor is it a murder mystery, where you find out what it's about on page 15 (that's all NSF allows). No, it's a proposal, where it pays to say what it's about right up top, and to say it in a way that is consistent with the goals of the agency from which you are seeking funding.