A Survey of Awards Given by the National Science Foundation for Projects in Multidisciplinary Engineering (1998-2004)

Joan Gosink
Catherine Skokan
Engineering Division
Colorado School of Mines

Abstract

During the past six years the National Science Foundation (NSF) awarded 528 grants for projects with multidisciplinary themes. Although most of the engineering-related grants deal with one or several of four themes: emerging engineering concepts, engineering science, basic engineering, and humanities/business/engineering combinations, rich information provided through the NSF data base provides opportunities for additional analyses. This paper classifies the 528 grants in terms of NSF program, collaborative partners, annual trends, geographic location, and funding level. The paper concludes with a review of successful strategies for grant-writing for multidisciplinary engineering projects.

Introduction

There have been numerous articles emphasizing the importance of interdisciplinary or multidisciplinary research to address emerging areas in science and engineering,[1, 2] to enhance the relevancy of undergraduate engineering education,[3, 5] and to utilize new technologies in innovative applications.[4] Specific topics, including bioengineering, engineering systems, and environmental engineering are often said to be inherently interdisciplinary. Nevertheless, there is a perception among some researchers that proposals described as interdisciplinary or multidisciplinary are at risk during the review process, and tend to fair less well in comparison with traditional disciplinary research proposals. This article represents a preliminary review of projects funded by the National Science Foundation (NSF) that are self-described as multidisciplinary with a particular emphasis on engineering projects. Data taken from the NSF Fast Lane website provide a source of information on these projects.

Methods

The NSF Fast Lane website[6] provides access to a wealth of information regarding funded projects. We used the search function at this site to identify ongoing projects related to "multidisciplinary" themes in the abstract, and downloaded spreadsheets summarizing this information. Clearly, other multidisciplinary or interdisciplinary projects, not identified as such in the abstract, may have been funded, but we assumed that the use of these terms in the abstract indicated an important area of emphasis. Our search was constrained to the years 1997-2004.

The spreadsheet data contains 25 columns: award number, project title, NSF organization, NSF program, start date, Principal Investigator (PI), U.S. State, university or organization, award type (standard or continuing), NSF Program Manager, expiration date, expected funding level, Co-PI, PI e-mail, five columns containing identifying information about the university or organization, NSF Directorate, NSF program number, NSF program reference or theme (such as manufacturing or SMET [science, math, engineering and technology]), field of award (a NSF assigned numeric reference number), award number, and abstract. Most of these column headings are self-explanatory. The program reference and field of award do not include categories related to multidisciplinary topics, nor to multidisciplinary engineering. Thus our analysis was based upon the content of the abstract of each project.

Analysis of the Data

Using the search word "multidisciplinary", 528 funded projects were located. The spreadsheet data provide a rich source of information. The following analysis only presents a portion of that which can be gleaned from the Fast Lane data bank.

In the next four sections, we investigate some of the facts provided through analysis of the spreadsheet. Although the projects can be categorized generally as four themes: emerging engineering concepts, engineering science, basic engineering, and humanities/business/engineering combinations, they can also be sorted according to the disciplinary participants in the multidisciplinary plan. Annual trends in funding levels for multidisciplinary projects were also observed. The number of funded projects and dollar value of the funding per state has been examined. Finally, we looked at the number of grants in several NSF divisions and programs.

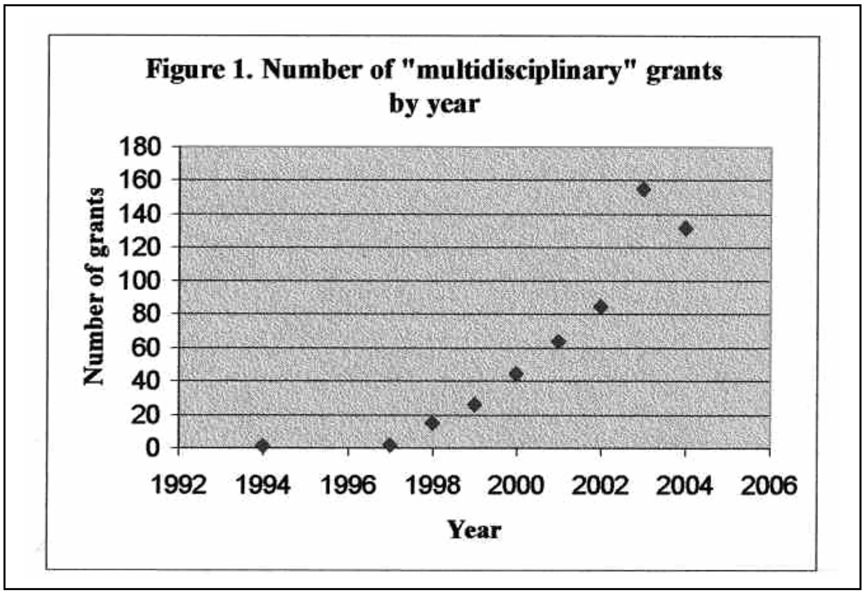
Participants in Multidisciplinary Projects

The 528 projects were first sorted by the categories of participants in disciplines listed in the abstracts. Various engineering fields working together or with non-engineering colleagues fall into six categories. For each of the categories listed below, an example of the cooperative team is also given:

- Cross-Engineering disciplines (for example Chemical Engineering/Mechanical Engineering/Electrical Engineering multidisciplinary project) 9%
- Engineering and Science (for example Material Science, Electrical Engineering, Physics multidisciplinary project) 28%
- Specialties within related disciplines (for example Molecular Biology, Cellular Biology, Diagnostics, and Therapeutics in a combined project; or a program of Computer Science with Computer Information Systems and Computer) 28%
- Science and/or Engineering and School of Education (for example Nanotechnology, Industrial Engineering, and K12 Teacher Preparation) 20%
- Sensors and a science or engineering application (numerous biomedical projects partnering with electrical engineering through sensor technology; also many multidisciplinary engineering undergraduate laboratories with sensors) 7%
- Engineering or science in combination with a liberal arts subject (for example linguistics, behavioral biology, psychology and computer science working together) 8%

Annual trends

We separated the awards by year. Two awards, one initiated in 1994 and another in 1997, are still active, and so are included in the results. In general, the number of "multidisciplinary" grants appears to be increasing, as shown in figure 1. However, this information may be misleading for two reasons: first, the data-base provides only those grants that expire in 2004 or later; and second, very recent 2004 grants may not be reported. In effect, the data-base is preferentially selecting grants awarded in 2004 and 2003. Nevertheless, it is encouraging to see the relatively large number of grants with multidisciplinary themes that have been awarded within the last few years.



Location and amounts of awards

The number of grants and the average award in each state in the U.S. follow:

State	Number of awards	Average award
Alaska	3	$1,034,705
Alabama	7	$1,135,382
Arkansas	3	$959,314
Arizona	20	$1,150,057
California	63	$1,734,502
Colorado	15	$877,950
Connecticut	4	$661,537
Washington DC	5	$1,420,699
Delaware	4	$475,179
Florida	20	$662,710
Georgia	16	$542,935
Hawaii	4	$321,412
Iowa	7	$965,673
Idaho	2	$1,403,276
Illinois	27	$752,930 ($9,949,733)
Indiana	14	$799,126
Kentucky	3	$295,755
Louisiana	7	$1,106,198

Massachusetts	25	$1,143,431
Maryland	15	$1,854,420
Maine	2	$851,971
Michigan	18	$1,935,318
Minnesota	6	$931,639
Missouri	9	$692,141
Montana	4	$1,585,422
North Carolina	15	$800,757
North Dakota	1	$103,308
Nebraska	4	$1,040,550
New Jersey	16	$770,869
New Mexico	4	$889,687
New York	48	$1,057,269
Ohio	17	$638,853
Oklahoma	4	$898,175
Oregon	4	$1,449,350
Pennsylvania	23	$1,142,766
Puerto Rico	2	$375,000
Rhode Island	4	$832,152
South Carolina	3	$906,599
Tennessee	6	$1,587,631
Texas	26	$754,819
Utah	4	$1,368,706
Virginia	19	$672,209
Washington	10	$1,558,222
Wisconsin	10	$1,002,447
West Virginia	2	$3,477,664
Wyoming	2	$1,780,315.

The largest number of multidisciplinary awards were allocated to California and New York. Other states with 20 or more awards include Arizona, Florida, Illinois, Massachusetts, Pennsylvania, and Texas. As anticipated, the number of grants tends to be large in the more populous states, and in states with large universities that emphasize science and engineering. Many of these amounts seem extraordinarily large; this is due to the fact that they may represent continuing grants (typically three year grants), multi-institutional grants such as engineering or science centers, and certain types of contracts or cooperative agreements. For example, the National Computational Science Alliance at the University of Illinois at Urbana-Champaign was funded as a continuing grant for $29.5M. For reference, in the above list, we have included an average grant amount of $752,930 for Illinois *without* the Computational Alliance, and $9,949,733 *with* the Computational Alliance. Presumably, many of the other state averages would decrease appreciably if centers and special contracts were overlooked in the computation of the average.

NSF programs for awards

Multidisciplinary awards occur in almost every NSF organization. The distribution of these grants in terms of NSF Divisions follows:
Division of Astronomical Sciences (AST) – 1
Division of Atmospheric Sciences (ATM) – 1
Division of Behavioral and Cognitive Sciences (BCS) – 2
Division of Bioengineering and Environmental Systems (BES) – 24
Division of Computing and Communication Foundations (CCF) – 12
Division of Chemistry (CHE) – 21
Division of Civil and Mechanical Systems (CMS) – 34
Division of Computer and Network Systems (CNS) – 13
Division of Chemical and Transport Systems (CTS) – 19
Division of Biological Infrastructure (DBI) - 5
Division of Environmental Biology (DEB) – 6
Division of Graduate Education (DGE) – 145
Division of Design, Manufacture and Industrial Innovation (DMI) – 17
Division of Materials Research (DMR) – 161
Division of Mathematical Sciences (DMS) – 18
Division of Undergraduate Education (DUE) – 33
Division of Earth Sciences (EAR) – 7
Division of Electrical and Communication Systems (ECS) – 48
Division of Engineering Education and Centers (EEC) – 28
Emerging Frontiers (EF) – 3
Experimental Program to Stimulate Competitive Research (EPS) – 5
Division of Human Resource Development (HRD) - 5
Division of Integrative Biology and Neuroscience (IBN) – 3
Division of Information and Intelligent Systems (IIS) – 8
Division of Molecular and Cellular Biosciences (MCB) – 8
Division of Ocean Sciences (OCE) – 4
Office of International Sciences and Engineering (OISE) – 24
Division of Physics (PHY) – 4
Division of Research, Evaluation and Communication (REC) - 1
Division of Shared Cyberinfrastructure (SCI) – 3
Division of Social and Economic Sciences (SES) – 2

Two divisions, DMR and DGE, awarded the largest number of multidisciplinary grants, but even the more traditional, discipline-specific programs, such as CMS and ECS each awarded more than 30 grants. This is encouraging for engineering researchers with interests in multidisciplinary projects.

Another way of breaking down the data is to consider specific NSF programs within or across divisions. Some specific programs cross Division boundaries, and therefore may be particularly relevant to the consideration of multidisciplinary endeavors. A list of specific programs and the number of funded, multidisciplinary projects follows:

Program abbreviation	Program	Number of awards
CAREER	Faculty Early Career Development	27
Coll.Res.	Collaborative Research/ Americas Program	15
CNCI	Controls, Networks, and Computational Intelligence Integrative Systems	10
CCLI	Course, Curriculum and Laboratory Improvement	24
EPDT	Electronics, Photonics, and Device Technologies	24
EEC	Engineering Education	12
EPSCOR	Experimental Program to Stimulate Competitive Research	12
HRD	Human Resource Development	33
IGERT	Integrative Graduate Education and Research Training	50
Inter America	Inter-American Materials Collaboration	15
ITR	Information Technology Research	10
MRI	Major Research Instrumentation	26
NIRT	Nanoscale Interdisciplinary Research Teams	12
OMA	Office Multidisciplinary Activities	11
Sensors	Sensing and Sensing Technology	10

Writing Successful Multidisciplinary Proposals

As the data show, many multidisciplinary projects are funded through the Division of Undergraduate Education (DUE) or the Division of Engineering's program for Integrative Graduate Education and Research Traineeships (IGERT). These and many other NSF programs utilize the panel review system almost exclusively, rather than traditional individual mail reviews. Panel reviews have several characteristics that differentiate them from the individual mail review process, and these differences suggest that the content of the proposal should be adjusted accordingly. First, all panelists are generally assigned a fairly large number of proposals, typically 10-14. Panelists meet at a NSF-designated site and review the proposals as a group. Often, the logistics are set up such that the panelists read 3-4 proposals, write individual comments, reconvene and discuss the proposals (possibly changing their reviews). Panelists take turns serving as reporter with the responsibility of writing a summary of the discussions. Panel members may read the proposals ahead of time; however, this is not required in many NSF programs, notably the DUE programs.

The panel review process is therefore intense and time-limited. Panel members have a specific window of time to review several proposals, and these probably span several disciplines, or at least several fields within a single discipline. This suggests that successful proposals must be both extraordinarily clear and well organized. Tables, bullet-items, and clear graphics that convey important concepts succinctly and visually are devices that can be used effectively for this purpose. Long and detailed discipline-specific discussions should be minimized.

Second, in general the panelists will be selected from both academic and industrial sources, and will possess diverse engineering credentials. Thus the effective level of disciplinary focus of a panel-reviewed proposal will be different from that of a mail-reviewed proposal. The level of expertise should be that of a knowledgeable and professional colleague, rather than that of a competing researcher. Panelists may not have a professional knowledge of the value of the research topics. It is therefore contingent upon the proposal authors to convince the reviewers of the importance of the research topic. The value of the research may be emphasized in the introduction through expert commentary. This commentary may take the form of references from engineering authorities, such as the National Academy of Engineering, industrial spokespersons, ASEE articles, NSF studies, and similar sources. Letters of support from industry or national laboratories are especially helpful in conveying the need for the research. Similarly, surveys from industry or federal sources, which highlight shortages of critical information or of knowledgeable entry-level engineers in the field, can provide legitimacy for the requested grant.

It is also less likely that the panelists will know the proposal authors. Therefore, the précis of previous work must be convincing and relatively detailed. The section of the proposal that summarizes the authors' current and pending research should also be up-to-date.

Third, it will be important to convince the more traditional members of the panel – those with limited or no experience in multidisciplinary research – of the benefits of the multidisciplinary approach. Again, references from impeccable sources, such as those listed above may be helpful. The proposal author should be able to demonstrate the synergism that can be obtained through multidisciplinary collaboration. This may occur when instruments, techniques, protocols, or computational methods from one discipline are brought to bear on research problems in another discipline.

Finally, the breadth of experience of panelists will generally be greater than that of the discipline-specific mail reviewer. The panel may include experts on educational theory or assessment, community college faculty, and college administrators. Thus the proposal authors should not overlook the "support" components of the proposal, such as: assessment, dissemination, project management, K-12 and other outreach activities, and attention to diversity issues. Each of these sections must be taken seriously, with thoughtful consideration of the proposed strategies.

Conclusions

A database of 528 current awards granted by the NSF with the designation "multidisciplinary" in the abstract was reviewed in order to provide information about award locale, amounts, NSF program, and areas of emphasis. The projects are distributed widely throughout the U.S. and include many of sizeable value. California and New York lead the country in total number of multidisciplinary projects. The number of multidisciplinary awards seems to be increasing; however, this interpretation should be treated with caution, since the database preferentially selects current projects.

In summary, virtually every NSF program, including the more traditional discipline-specific programs, has given grants for multidisciplinary projects. Two NSF programs, Division of Materials Research and the Division of Graduate Education, stand out in this regard. The grants can be classified into six groups, and these have the following indicated frequency:

- Cross-Engineering disciplines 9%
- Engineering and Science 28%
- Specialties within related disciplines 28%
- Science and/or Engineering with an Education emphasis 20%
- Sensors and a science or engineering application 7%
- Engineering or science in combination with a liberal arts subject 8%

When multidisciplinary proposals are reviewed by the panel review system, rather than by individual mail reviews, it is prudent to consider modifications to the proposal that are responsive to the panel review process. Discipline-specific jargon should be decreased, and rationale for the project strengthened. Consideration should be given to the time limits imposed upon panel reviewers.

Finally, the NSF FastLane system provides a rich source of information regarding funded projects. Databases and publications obtained online can provide statistics relevant to proposal preparation and proposal strategy.

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Biographical Information

CATHERINE SKOKAN

Catherine K. Skokan (cskokan@mines.edu) received her Ph.D. in Geophysical Engineering from the Colorado School of Mines. She is presently an Associate Professor of Electrical Engineering at Colorado School of Mines. Her research interests include engineering applications of geophysics, curriculum development, and K-12 outreach.

JOAN GOSINK

Joan Gosink is an Emerita Professor and former Director of the Engineering Division at CSM, the largest department or division in the School. Under her direction, the Division received various accolades, including designation as a Program of Excellence from the Colorado Commission on Higher Education. The program also expanded to include Masters and Doctorate degrees and an undergraduate specialty in environmental engineering. Dr. Gosink twice served as a Program Director at NSF, and is an experienced ABET evaluator.