

National Academies Evaluation of the VIGRE Program Is Released

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In the 1980s and 1990s, there was concern within the mathematical sciences community that postsecondary education in the mathematical sciences was in trouble. A series of challenges was identified in important national reports, including in particular the following:

- *Renewing U.S. Mathematics: Critical Resource for the Future* (1984), also known as the David Report after the chair of the committee, former Presidential Science Advisor Edward David;
- *Educating Mathematical Scientists: Doctoral Study and the Postdoctoral Experience in the United States* (1992), also known as the Douglas Report after committee chair Ronald Douglas; and
- The report of an international panel convened by the National Science Foundation (NSF), *Report of the Senior Assessment Panel for the International Assessment of the U.S. Mathematical Sciences* (1998), also known as the Odom Report after panel chair General William Odom.

Together, these reports painted a picture of the mathematical sciences that focused on three major challenges: inadequate funding, insufficient numbers of students interested in mathematics, and shortcomings in the shape and direction of postsecondary mathematics education. These reports raised four issues concerning students: (1) the number of students receiving degrees, (2) the lack of racial and gender diversity among the mathematics graduate student body, (3) the declining fraction of U.S. citizens receiving advanced degrees in mathematics, and (4) the lack of sufficient

postdoctoral fellowships for new doctorates. Four issues were identified with respect to the structure of training in the mathematical sciences: (1) the need for increased breadth, (2) providing a better balance of education and research, (3) decreasing the time to degree, and (4) creating a more positive learning experience.

In response to all of these concerns, Donald J. Lewis, then director of the Division of Mathematical Sciences (DMS) at NSF wrote a “Dear Colleague” letter to the mathematical sciences community, based on recommendations of a DMS Special Emphasis Panel, which introduced and justified the Grants for Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE) Program. The panel recommended that the VIGRE program enable departments to carry out innovative educational programs at all levels not possible through (then) current departmental resources, and it saw the program achieving a change of culture in departments resulting in broadening opportunities through new curriculum development and research experiences. Although the goals of the VIGRE program have changed from year to year, they have consistently included

- Integration of research and education;
- Enhanced interaction across undergraduates, graduates, postdoctoral fellows, and faculty;
- Broadened educational experiences of students to include workforce and early research opportunities; and
- More students motivated to study mathematics and statistics.

VIGRE has been a continuing program of DMS since 1999, but it had not been externally evaluated until NSF requested the appointment of a committee of the National Research Council’s (NRC) Board on Mathematical Sciences and Their Applications in 2007 (see sidebar). The charge to this committee included the evaluation of past and current prac-

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Committee to Evaluate the NSF's
Vertically Integrated Grants for
Research and Education (VIGRE)
Program

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tices for steering and assessing the VIGRE program and recommendations on how to improve the program. At about the same time, NSF also commissioned a report, *Increasing the Quantity and Quality of the Mathematical Sciences Workforce through Vertical Integration of Cultural Change*, by Margaret Cozzens. This report recounts some successes of the VIGRE program but is not meant to be a formal evaluation.

The NRC's report, *Evaluation of the NSF's Program: Grants for Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE)* was

released in August 2009 and is available from the National Academies Press (<http://www.nap.edu>). It is the result of four meetings over two years during which the study committee interviewed NSF program managers, leaders, and some students involved with VIGRE programs that were successful (renewed) and leaders of some programs that were not renewed or were canceled before the scheduled five-year expiration, and people involved in site visits preliminary to the selection of awardees or to VIGRE grantees at their three-year evaluation point. The committee was also able to review a substantial amount of data collected by NSF and data in site-visit reports and proposal evaluations, although it was denied access to data that NSF is required to keep confidential. The committee conducted an independent survey of all doctorate-granting departments in the U.S. to determine faculty and administration attitudes toward VIGRE and used much of the data collected annually by the American Mathematical Society.

VIGRE began in 1999, so its first grants wrapped up only five years ago, and some of them were renewed and are only now finishing. Because change of the sort envisioned by VIGRE is necessarily slow, as are trends in enrollment and composition of mathematics student bodies, neither NSF nor the NRC expected that this evaluation would be able to discern strong indications of the effectiveness of the program. In addition, data and impressions from interviews are often contradictory, or at least not sufficient to draw firm conclusions, adding to the difficulties in attributing effect to cause in the presence of so many confounding variables. Nevertheless, the committee was able to reach a number of conclusions concerning the VIGRE program and make recommendations for improvements.

The program's instances of clear success suggest that it provides real value, but its instances of failure suggest that some change is needed, and so the committee recommended that the VIGRE program be continued with some programmatic changes. The most important of these changes is that NSF allow greater flexibility in the design of individual grants by giving consideration to proposals that address only some of the goals of the VIGRE program—to date, such proposals would not be entertained—and that there be scope for greater local initiative in finding ways to achieve these goals. Although it is a worthy aspiration for VIGRE program requests for proposals to call simultaneously for vertical integration from undergraduate education to postdoctoral research; for department-wide change across all subdisciplines; and simultaneous and significant change in a department's undergraduate, graduate, and postdoctoral programs, this should not be seen by NSF as the only path to achieving the goals of the program or to realizing the recommendations of the national panels. The committee has seen many examples of benefits to education, breadth of experience, and culture from interactions across *some* vertical divisions, such as postdoctorals mentoring graduate students or graduate students mentoring undergraduates. The experience of the committee members is that there are benefits to connectivity; but it did not see evidence that *all* of those elements of vertical integration need to be present in a department in order to see any benefits. For example, proposals that build on the particular strengths of a department might not necessarily span all educational levels from undergraduate to postdoctorals, and they might involve fewer faculty members but with more release time for each. Another possibility is the inclusion of students preparing to apply advanced mathematics to nonacademic settings, such as those in a professional master's program. Allowing for greater flexibility might encourage institutions with innovative but less inclusive ideas to submit proposals to the VIGRE program. It is notable that NSF has independently broadened its offering of workforce programs through initiatives that complement the VIGRE program, and this recommended broadening of VIGRE is consistent with that larger trend.

The committee recommended that the goals of any future VIGRE program be clear, consistent, and well publicized. In all phases of the award process, the focus must be on both programmatic quality and scientific quality. Data required from proposers and awardees should concentrate on a small number of carefully chosen benchmarks.

Some departments that responded to the committee's survey email felt that the burden of proposal preparation, requiring extensive departmental participation and coordination, was not

commensurate with the likelihood of receiving an award. A less burdensome preliminary process might also encourage greater institutional participation. For this reason, the committee recommended that a preproposal step be inserted into the VIGRE application process.

There have been numerous successful individual activities instituted by VIGRE grantees; many of these are included in Margaret Cozzens's book. For example, North Carolina State has begun an "Environmental Statistics Practicum" linking statistics undergraduates and clients; and the University of Chicago brings large numbers of students in grades 7 through 12 for a summer mathematics enrichment program. The University of Illinois at Urbana-Champaign introduced a Research Experience for Graduate Students (REG) to give graduate students in their first and second years an early research experience. The University of Wisconsin introduced Collaborative Undergraduate Research Labs (CURLs) where teams of undergraduates, graduates, and faculty explore mathematical topics, both pure and applied. The University of Washington conducted a Workshop on Working in Industry to inform graduate students and postdocs about careers in industry and national labs. UCLA offers opportunities for graduate students to dip their toes into applications through a program of graduate summer internships with professors in the sciences, engineering, and medicine.

NSF has not established any formal way to ensure that successful initiatives sponsored under VIGRE awards can be maintained at the conclusion of awards. To remedy this, the committee recommended that NSF convert the VIGRE program to one with longer-duration awards: a norm of ten years, if a five-year review is satisfactory, though the second five-year award might be smaller and more focused than the initial award. Accompanying this change, the committee recommends that NSF require winning departments' home institutions to make a commitment to sustain successful new initiatives resulting from VIGRE as the NSF funding phases down.

NSF needs to develop quantifiable goals for the VIGRE program and link these to consistent data requirements for all grantees and throughout the life of the VIGRE program. These steps will aid in maintaining a transparent evaluation process for the revised program and enable NSF to track the successes of individual VIGRE grants, thus informing future decisions about program continuation.

The committee observed that successful innovations at VIGRE sites were not being publicized in a way that maximized the potential for their being implemented at other universities. NSF should take the lead in developing a framework and infrastructure for a central source for information and communication regarding the successful initiatives of individual VIGRE awardees. In addition, all

awardees should maintain and provide access to a VIGRE website even after the expiration of their VIGRE awards; and departments should be encouraged to disseminate examples of their VIGRE activities by, for example, developing resources that could be picked up by other departments.

VIGRE is a program designed to increase departmental interaction and cooperation, but it excludes a large portion of the graduate student and postdoctoral population—foreign nationals. Although they may participate in VIGRE activities, they are ineligible for financial support. This decision may be out of NSF's control, but the committee believes that the goals of the VIGRE program as well as the national need to recruit the most talented people worldwide for positions in academe, industry, and government would be well served by the inclusion of foreign nationals in the program. This recommendation is in line with the 2005 report, *Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States*, written by the National Research Council's Committee on Science Engineering and Public Policy.

Although it is difficult to attribute changes in an institution's mathematical sciences department to its VIGRE grant as opposed to other factors, the committee believes that the VIGRE program has produced a number of qualitative changes in mathematics and statistics departments that have held a grant and, through the proposal process, even some that haven't. These include increasing the integration of students and faculty, providing more early opportunities for student research, helping create a more welcoming culture for mathematics education at all levels, and offering a broader and more interdisciplinary range of options.