

VIGRE at the University of Arizona

Department of Mathematics and
Program in Applied Mathematics
University of Arizona

November 17, 2008

1 Award Letter Questions

In preparing our answers to the questions that follow we found that there is a great deal of overlap and even repetition for the simple reason that our programs are tightly integrated and components often serve several functions at once (integration of research and education, broadening of horizons, professional development, mentoring, recruitment, ...). Nevertheless, for the sake of simplicity we have kept the format of the questions as presented in the award letter. Our answers assume some familiarity with the mathematical sciences at the University of Arizona and the relationship between the Mathematics Department and the Graduate Interdisciplinary Program in Applied Mathematics.

1.1 How well has the integration of research and education been achieved at all levels?

The integration of research and education has long been a hallmark of the mathematical sciences at Arizona.

At the graduate level, our students engage in research early in their careers via the Research Tutorial Group program. They speak in research seminars as well as their own colloquia and they learn to make the case for their projects through our competitive fellowship application process. They are frequently involved in undergraduate research projects. Graduate student mentors are a key component of our summer research program for undergraduates. All the components of our PhD programs are designed to contribute both to the intellectual growth and to the balanced professional development of our students and this leads to a natural fusion between research and education.

Our undergraduate majors have many opportunities to integrate inquiry-based learning with activities that enhance their communication skills and analytical capacities via undergraduate research projects, teaching assistantship and internship opportunities, and participation in our summer research program.

Our post-doctoral fellows partake of this integrated culture and have contributed to it in many ways. For example, VIGRE post-doc Chris Bergevin has brought his research expertise to bear in collaborating with faculty in mathematics and biology to design and teach new curricula in calculus, differential equations, and statistics for the biological sciences. We anticipate that post-docs Paul Dostert and Andrea Young will be centrally involved in the next two Arizona Summer Programs, on computational photonics and geometric analysis respectively.

1.2 How is your EMSW21 program broadening education at all levels?

All of our programs seek to produce well-rounded mathematical scientists with broad professional development experiences.

Graduate students in the Department's PhD program all master a broad core of fundamental mathematics as well as the material necessary for their research speciality. They all take at least two graduate courses outside the department. Beyond their core courses, graduate students in the Program in Applied Mathematics take between three and six graduate courses in other departments and many of them have advisors from other units (chosen from over 20 departments in five colleges across campus). All of our students fulfill

broad communication skills requirements and they have many opportunities for professional development ranging from internships to peer tutoring and outreach to local high schools.

Our undergraduates also have many opportunities to develop a broad mathematical perspective. Our undergraduate major has seven options ranging from traditional core mathematics to economics, applied mathematics, life sciences, and mathematics education. We have an extensive program of undergraduate research and an undergraduate teaching assistantship program. Many of our students participate in the summer programs in Budapest and Moscow, REU programs at a number of sites, and internships at companies or national labs. (Our undergraduate web site has an impressive list of options.)

Our post-doctoral associates have large opportunities to broaden their research horizons. Our inclusive culture allows them to participate in research seminars of many flavors, to be involved in planning major conferences such as the Arizona Winter School, and to develop interdisciplinary interests through the many projects of the Program in Applied Mathematics and the cross-disciplinary activities of many of the department's faculty and research groups. Our postdocs are also broadly involved in the department's outreach and educational programs both at the K-12 and undergraduate levels.

1.3 How has your EMSW21 program improved the instruction skills and communication skills of students and post-docs?

Our graduate students benefit from a carefully planned training program for new instructors and a strong mentoring and oversight program as they begin their teaching careers. As they progress they have the opportunity to teach a variety of courses and to participate in many instructional and peer-mentoring programs, ranging from weekend programs for high school students to our integration workshop for new graduate students and peer tutoring. They may become super-TAs and contribute, through problem sessions, office hours, and peer tutoring, to our core graduate and undergraduate courses.

Communications skills are also an integral part of our PhD programs. Students engage in the full cycle of research, writing, and speaking early in their PhD programs, they often write term papers in courses, and they are required to complete a communication skills requirement that includes a web page, a CV, and the development of texts suitable for a range of audiences.

Our undergraduates have many opportunities to develop their communication skills. For example, our undergraduate teaching assistant (UTA) program gives students the chance to be actively involved, via tutoring and office hours, in lower-level mathematics instruction. Undergraduate Research Assistants (URAs) are supported by VIGRE travel funds to present their results at national meetings.

Our postdocs have contributed significantly to programs aimed at the critical transitions of mathematics workforce development. This includes, for example, team teaching of core courses for the various tracks of the math major, assisting with the organization of the integration workshops, and participation in vertically structured research working groups. Moreover our postdocs are supported both financially and through mentoring to present the results of their research and educational activities in national forums.

1.4 What has been the effect of the mentoring programs that have been developed?

Arizona has long had a well-developed mentoring program for graduate students, post-docs, and undergrads. The main new component made possible by this VIGRE project is the "integration workshop" for incoming mathematics PhD students. This "boot camp" was described in Section 4.1.2 of our proposal. One important effect of this activity is that we have a much deeper understanding of the strengths and weaknesses of our incoming students and therefore we are better able to advise them with respect to their first-year program. This has resulted in much lower attrition in the first two years of the program, as well as better results on qualifying exams. The closely supervised professional skills seminar for first year applied mathematics students, which involves laboratory-based team projects, has helped them develop an early appreciation of research methodologies, team work, and presentation skills.

An additional, and important, component of our mentoring program has been our two-step system of competitive proposal writing for VIGRE support in which we give the applicants feedback and advice on how to improve their first submissions. This scheme has helped teach our students how to write clear and

well organized proposals. We have been struck by the success of this component of our VIGRE project: last semester alone we received 23 high-quality proposals.

1.5 How has your EMSW21 program promoted recruitment into the mathematical sciences?

There are at least three significant ways in which our project has contributed to recruitment into the mathematical sciences.

First, through an aggressive campaign to make the benefits of more training in mathematics better known, Associate Head for Undergraduate Affairs William Velez and his team in the math center have increased the number of math majors at the University from 472 in 2006 to the current number of 525. Graduation numbers have also increased. In 2006, a total of 62 degrees were awarded, while in 2008 it rose to 81. The number of minors has remained around 500. This number is more than double what it was about five years ago. We are also seeing a significant increase in the demand for advanced courses such as the year-long sequences in analysis and algebra and in such topics as mathematical modeling and cryptography.

Second, the Arizona Summer Program promotes recruitment into the mathematical sciences in two complementary ways. Most obviously, the excitement and satisfaction of a successful research program inspires many students to continue their mathematical training. At least 44% of the students in the 2007 summer program have continued on to graduate school in mathematics or applied mathematics. Another 22% have entered careers with a significant mathematical component (teaching or NSA). Several presented the results of their summer research at AMS or MAA meetings and at least one won a “best paper” award. A second and perhaps ultimately more significant effect comes from the participation of our network partners in the summer program. Faculty from institutions without the capacity to field full VIGRE projects come to Arizona and participate in a summer program that they can use as a model for a program at their own institution. (The first two Arizona Summer Programs had visiting faculty from the University of Texas Pan American and Colorado State University.) The summer program have also produced exportable modules in mathematical modeling and computational group theory which can be used at other institutions.

Third, minority recruitment continues to be of high priority for the math center. William Velez has continued with his “Minority Calculus Advising Program.” In fall 2008, Velez met with more than 100 minority students for twenty-minute appointments. This advising program continues to recruit minority students into the mathematics major. In the last four years, nine Native American students have received bachelor’s degrees in mathematics. Of the 81 mathematics majors who graduated in 2008, 14 were minority students. Currently, 24% of the mathematics majors are minority students.

1.6 How has the interaction of several levels of students and faculty been enhanced?

Several components of our VIGRE project enhance interactions between students at various levels and faculty. These include the integration workshop, the research tutorial group (RTG) program, the Applied Mathematics laboratory, the undergraduate teaching assistant and research assistant (UTA and URA) programs, and the Arizona Summer Program.

1.7 What is your EMSW21 program doing to affect the time to degree?

The structure of our programs and the preparation of our students makes a time to degree of five or six years appropriate in the vast majority of cases. Our project has focussed less on “time” and more on “to degree” in other words, on lessening attrition and making sure that more students leave the program with a degree and with well rounded education and professional training. Careful mentoring together with components such as the integration workshop and the research tutorial groups have indeed resulted in less attrition in recent years. For example, historically, the fraction of matriculants who obtain a PhD has been about 40%, but retention numbers in the last five years have been significantly higher: for students entering in 2007, 2006, ..., 2003, the number who are on track for a PhD (or have already graduated with a PhD) is 91%, 81%, 50%, 63%, and 65%. Time to degree continues to average slightly less than 6 years.

1.8 Has there been effective dissemination to the mathematical sciences community of the results of this activity?

Many details about our VIGRE project are available on our web site (<http://math.arizona.edu/~vigre>), including the proposal, annual reports, student reports, and reusable material from the summer programs.

Another important dissemination effort has been the Southwestern Network. We have had two network meetings, one focussed on several issues related to the flow of students between or programs, and the most recent one focussed on the teaching of proof in the undergraduate curriculum. Network members have participated as faculty mentors in both Arizona Summer Programs held so far, and we have recruited students from network schools into our graduate programs.

A third important dissemination effort has been carried out by William Velez, who has travelled to several institutions in the region and shared his experiences and insight into minority recruitment into the math major.

1.9 Can you identify other changes that EMSW21 has made possible and that may not have occurred with out the EMSW21 program at your institution?

VIGRE II has had two major effects:

First, it has allowed us to establish a Southwestern Network and Arizona Summer Program which have fostered an exchange of ideas and personnel in the region supporting VIGRE goals.

Second, it has allowed us to consolidate and make permanent the array of educational and professional development opportunities available to our students and post-docs. The commitment by the University of Arizona central administration to 10 new graduate fellowships starting in the academic year 2011-2012 is a large bonus which will allow our students to take advantage of these many opportunities and to enter the workforce with excellent scientific and professional preparation.