

Project Description

1 Introduction: Vision, Objectives, and Scope

Louisiana State University is located in the Mississippi Delta on the edge of Cajun Louisiana with its rich and diverse culture. The Department of Mathematics has grown and developed into a strong mathematics department. (Please see p. 5 for details.) The Department has a proven track record of success with minority students, an extensive history of outreach on which to build and expand the mathematical pipeline, and an active mathematics education group. LSU is the state flagship university, our undergraduate program attracts some of the strongest regional students. The Department enjoys the support and respect of the University and the State. The Department proposes a comprehensive workforce proposal for the region. The major goals of the program are:

- To increase the number of well-prepared US citizens who pursue careers in the mathematical sciences and in other NSF-supported disciplines. (In this proposal US citizens will include permanent residents).
- To have indirect impact by including the participants from other scholarship/fellowship programs for US citizens in all VIGRE activities thereby improving the training of the participants
- To have indirect impact by creating educational infrastructure that will permanently extend the impact of VIGRE to nearly all students in LSU mathematics programs.
- To broaden the background, perspective, and opportunities for exposure to mathematical culture and activity for regional students—especially minorities.
- To develop best-practice models that can be imitated and further developed. In fact, we view two of the proposed programs as the next step in development of best-practice models developed elsewhere in the VIGRE programs.

VIGRE support will enhance ongoing activities in vertical integration, workforce development, education and student research experience moving the Department from a solid program to one that can serve as a role model for mathematics departments in the South. The central focus of all planned activities is to improve and broaden the mathematical experiences of our students, to enhance their post-graduation research prospects, and increase the number of mathematics students. The proposed activities will enhance the interaction between faculty members and students through involvement in the *research crews*. The undergraduate component of the VIGRE proposal will provide exceptional opportunities to prepare undergraduate mathematics majors for mathematical or scientific careers and for graduate study.

The Department has a substantial number of individual research grants, some of which support students. In addition the Mathematics Department participates in federal programs that support US students: NSF/GK-12, NSF/S-STEM, Robert Noyce Scholarships, GAANN, and NSF/IGERT. The Department and its students are also fortunate to benefit from strong state support. The Department regularly gets *Enhancement Grants* from the State Board of Regents in a constitutionally mandated program, which is funded from oil royalties. *It is part of the vision in this proposal to build a permanent vertically integrated educational infrastructure* that will benefit all LSU mathematics students, however it will be of particular benefit to students in the above programs. Each program presently has its own system for professional development and research experiences. In several of the programs mathematics competes with other disciplines. A coherent system of vertically integrated educational infrastructure will be of benefit in several ways: (1) It will give the students stronger mathematically grounded professional development and broader mathematical experiences than presently available; (2) It will attract more students to mathematics by presenting clearly visible opportunities; (3) It will be a great addition to future STEM scholarship proposals and make it more likely to secure future scholarship/fellowship funding for mathematics students. Every math major will benefit since every student is required to have a capstone experience, and the infrastructure will heavily impact the capstone experience. The primary piece of this infrastructure will be the *research crew* (see p. 13).

The VIGRE program will be a catalyst to help transform the mathematical culture among our graduate students and motivate them to apply for research positions after graduation (see p. 8). In short, it will help

to place our graduate students more regularly in research postdoctoral positions and enhance the success rate of our US students. The Department has recognized that, in addition to traditional reading and classroom lectures, it is important for students to experience group projects and enjoy active research experiences and interaction. This will take place in the research crews. It is part of the vision in this proposal to broaden the opportunities of graduate students in all specialties to enter into mathematics careers outside the traditional research and education path (see p. 14).

It is our vision to transform our existing postdoctoral and visiting researcher program into a solid, flourishing postdoctoral program that can be sustained after the duration of the program. We will integrate the postdoctoral associates into our vertical educational and research activities. This goal can be accomplished as the University has made a substantial commitment to the Department to continue to fund a postdoctoral program at the conclusion of a successful VIGRE grant (see p. 15).

It is part of the vision in this proposal to expand the influence of VIGRE and LSU in our region to broaden and deepen student's mathematical experiences. The Department plans on expanding its regional influence at the college level by including a consortium of colleges and universities in its VIGRE summer program. Louisiana and Mississippi are the states with the greatest proportion of their populations African-Americans, which is an important fact in shaping the local culture. Alabama is sixth in the nation. The VIGRE summer program is structured to encourage minority participation. The program will also bring in regional faculty—a chance to learn from each other about mentoring students from diverse backgrounds reflective of our region. Furthermore the program will leverage some of LSU's existing outreach science/mathematics programs and mathematics secondary teacher education programs. The high school science and mathematics programs will benefit by a more thorough involvement of mathematics and an effort that may recruit more high school students to mathematics. College students will benefit by developing a deeper understanding that is required to work and communicate with high school students and teachers.

It is also part of the vision in this proposal to positively affect the attitudes of the high school students toward mathematics on a statewide level. The Department expects to do this using two new vehicles: The summer program previously mentioned and the High School Mathematics Circuit (see p. 19).

This proposal describes our strategy for attaining these objectives. The proposal builds on existing strengths of the Department, on recent initiatives and changes suggested by both external and internal curriculum review panels, on ideas developed in the preparation of previous VIGRE proposals, and on feedback from those proposals. We have incorporated best-practice notions and other ideas from successful VIGRE departments: Arizona, Chicago, Georgia, and Utah, but we have further developed and adapted them for LSU.

Scope: The Department is well prepared to act on the goals of the EMSW21 program. This proposal will engage the entire Mathematics Department at LSU. Each of the existing research groups will be involved in some aspect of integrating research with teaching, or outreach. Students have additional opportunities through project support from several interdisciplinary research institutes. A consortium of colleges and universities will involve regional faculty and students.

Impact at LSU and beyond: If funded, this proposal will have a great and long-term impact on the Department producing lasting and meaningful educational infrastructure. It will dramatically upgrade ongoing efforts to bring greater vitality and strength to its overall program. The vigorous innovation currently underway within the Department and the strong financial support now being provided by the University would multiply the effect of a VIGRE grant to create a unique opportunity. The present efforts and institutional financial support will strongly magnify the impact of a VIGRE grant and enable the Department to realize the objectives stated here and to maintain them long beyond the duration of a VIGRE grant. Through the summer VIGRE-REU and the regional consortium the proposed activities have a multiplying effect on undergraduate research experience and culture at all involved colleges. The proposed educational infrastructure could be a best-practice model on the national level for incorporating undergraduate research in an efficient and practical manner.

2 Outcome of Curriculum Review

The Department has constantly been reviewing its graduate and undergraduate program since 1998 when we started to prepare our first VIGRE proposal which was submitted in 1999. Additional review was in response to external program reviews in 1999 and 2004. Of importance for this proposal in these reviews were recommendations that the Department should start an Applied Mathematics program, introduce capstone courses for senior mathematics majors, and focus hiring in areas of departmental strength. In addition, the Department introduced undergraduate concentrations, undergraduate gateway courses, a number of new graduate courses, and a new format for graduate qualifying examinations. A discussion is now taking place on how the expansion of Applied Mathematics and Computation will affect our course offering and the structure of our program.

As a result of this reform, the total number of Mathematics majors and graduate students has increased, and enrollment in advanced undergraduate and graduate courses is up, as shown below based on fall enrollments each year.

MAJORS IN MATHEMATICS, ALL LEVELS								
	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Increase
UG Math Major	88	90	86	103	180	217	218	147.7%
MS	10	6	5	6	12	11	11	10%
PhD	47	56	67	77	77	77	82	74.5%

The number of undergraduate majors increased by 33% from 2000/01 to 2004/05 and by 148% from 2000/01 to 2006/07 compared to the 20% increase proposed in our first VIGRE proposal! It should be remarked, that *even without the new concentration in secondary education the increase in the number of Mathematics Majors was 85% over the last five years.* Note that the information in the two tables is gathered at different times of the year.

UNDERGRADUATE MAJORS ACCORDING TO CONCENTRATION								
Fall of Year	Secondary Education	Pure Math.	Actuarial Sciences	Math Computer Sciences	Applied Discrete Math.	Applied Comm.Eng.	Not Declared	Total
2006	57	45	22	12	4	2	78	220
2005	64	40	18	9	10	0	76	217

The Undergraduate Program: Foremost among changes to the undergraduate program is the introduction of new concentrations, the redesign of the pre-calculus classes, and the institution of *Capstone Courses*, Math 4004, Math 4020, and Exst 4087. Math 4020 usually runs in conjunction with the *Mathematics Consultation Clinic*, a highly successful industrial mathematics program in which the students work on group projects proposed by local industry, government, or businesses. Math 4004 is a new capstone course in *Mathematics Education*. In Exst 4087, students work on statistics projects. This offering is for students in the Mathematical Statistics and Actuarial concentrations. The Department would like to expand the capstone offerings to pure and applied mathematics using infrastructure proposed in the VIGRE program. Capstone approval is also given for the substantial number of individual faculty directed projects or participation in an NSF-REU. Every undergraduate student must have a capstone experience.

In Fall 2003, the Department began reducing the number of instructors and, at the same time, redesigned several lower-level service courses. A very successful form of teaching *College Algebra* and *Trigonometry* was initiated two years ago. The program is sometimes known as *Roadmap to Redesign* (R2R), for one of the early national grants that supported development in several universities (see the Undergraduate Program section). The Department has also introduced large lectures with an intense tutoring program to teach *Calculus with Business and Economic Applications*. Math 1100 *The Nature of Mathematics* has been redesigned to be a cultural mathematics course taught by a professor.

The Department introduced three new sophomore-level gateway courses to facilitate the transition to higher-level mathematics by topics oriented introduction to proofs. The one-year sequence in *Advanced Calculus* was revised and a new course in *Advanced Calculus of Several Variables* was introduced, see p. 11.

The Department introduced several new concentrations to expand on its traditional concentrations in core mathematics and computer science. These were *Actuarial Science*, *Applied/Discrete Mathematics*, *Applied/Communications Engineering*, *Secondary Mathematics Education*. After assessing the concentrations in 2005-6, it was decided to drop the under-enrolled *Applied/Communications Engineering* and add a new concentration in *Mathematical Statistics* designed by VIGRE Co-PI Larry Smolinsky, George Cochran, Padmanabhan Sundar, and Barry Moser from the Experimental Statistics department.

The *Secondary Education Concentration* meshes with a very strong outreach component of K-12 activities. The new *Mathematical Statistics Concentration* was developed in collaboration with the Department of Experimental Statistics. Students in the *Mathematical Statistics Concentration* will take a minimum of 4 courses in the experimental statistics department in addition to their mathematics requirements. Several new courses had to be developed for these concentrations. Among these are *Math 4050: Interest Theory* and *Math 4058: Elementary Stochastic Processes* for the Actuarial Sciences concentration and three new courses for the Secondary Mathematics Education concentration, which are run in tandem with courses offered by the College of Education. These education classes involve tutoring experiences, classroom presentations, and instructional strategies, as well as mathematical content.

The Graduate Program: The graduate offerings are now divided into three categories:

(I) Three *Core-1* courses: Algebra I, Analysis I, and Topology I for first-year doctoral students [1]. There is also a one-hour course entitled *Communicating Mathematics*, which is required each semester of the first year as a part of the professional development initiatives of the Department (see p. 9). Each summer we offer a review course for students who are preparing to take their PhD Qualifying exams.

(II) Six *Core-2* courses: Algebra II, Complex Analysis (as Analysis II), Differential Equations, Differential Geometry, Graph Theory and Topology II. Each doctoral student selects three of these in the second term of the first year, with a fourth required by the end of the second year for breadth.

The content of the Core-1 and Core-2 courses in algebra, analysis and topology were revised in 2006 and 2007. The Core-1 real analysis is now general measure theory and integration with emphasis on Euclidean space. It was taught in fall 2006. The Core-2 analysis course is now complex analysis instead of general measure and integration. The Algebra and Topology sequences have been revised as well. The revised courses will be taught in 2007-2008. Students are examined on the Core-1 courses and on one Core-2 course. Due to the redesign of the core sequences, we expect the Core-1 exams to become more difficult. is borne out in departmental statistics.

(III) Advanced courses: These are offered at regular intervals and include annually running second-year courses designed to provide breadth of training for every graduate student as well as specialized advanced courses and seminars that prepare students for research. Each departmental research group has a list of recommended courses [2]. A complete list of courses since 2002 can be found at [3].

Several other non-curricular changes have been made or are under consideration. In 2001 the Department introduced the *Graduate Student Picnic and Orientation Conference*, a one-day event where graduate students meet faculty members in a relaxed picnic atmosphere with some talks by faculty members. Last year, two graduate students presented their work and discussed life as a student at LSU. The Department has also experimented with more seminar style classes, where students read research articles or a part of a book and then give a presentation. The first of those classes was offered in Harmonic Analysis in spring 2006 and then in Combinatorics in fall 2006. Another is running now as the *Junior Topology Seminar*. To help students prepare for their job applications, material has been posted at the departmental web page, see [4]. It is interesting that we have received feedback from students using these resources from other universities.

Proposed Project

3 The Mathematics Department

The LSU Department of Mathematics has developed and grown and is now ready to be a regional leader in mathematics and education with higher aspirations. Our professional faculty is a diverse group in pure and applied mathematics with strong dedication to research, education, outreach, and university service. In the academic year 2006/07, 22 of our 53 professional faculty members were PIs of NSF-DMS research grants and one FRG supports two faculty. The number of NSF research grants will be larger in 2007/08. The NSF supported faculty are broad in their NSF areas of support: 5 in algebra and combinatorics, 2 in analysis, 6 in applied math, 1 in mathematical science priority areas, 1 in geometric analysis, 1 in scientific computation, 6 in topology. In addition, 2 faculty are PIs of NSA research grants, *thus 47% of our professional faculty were supported by federal mathematics research grants in 2006/07*. Two professional faculty are Co-PIs on grants in NSF-CISE. Other faculty are PIs or Co-PIs of important federal grant programs: NSF/IGERT, NSF/GK-12 and NSF/S-STEM, and US Department of Education GAANN.

The strength of the Department has been recognized by the LSU administration in several ways including giving support for substantial growth. In 2004 the Department was selected as one of only seven *Foundation of Excellence* departments of approximately 60 eligible programs [5]. The University is making opportunities available for leading mathematicians to visit LSU. Steele-Prize recipient R. V. Kadison will aid this effort visiting LSU for the spring semester of 2008.

The research of faculty members covers broad aspects of mathematics: algebraic number theory and algebraic geometry; algebraic topology, knot theory, gauge theory, and topological algebra; combinatorics and graph theory; abstract harmonic analysis and wavelets; representation theory. Research areas include applied fields: control theory; the mathematics of materials science; PDEs; probability and statistics; and scientific computation. In 2006/07 the Department had 13 assistant professors, 4 associate professors, 36 full professors and 3 postdoctoral associates. Seven of the assistant professors and 3 of the full professors were hired since 2004 as the Department started to focus on a new hiring plan. Three of the new faculty are women and two are former VIGRE postdoctoral associates. The others have several years of research experience, including postdoctoral positions.

In spring 2005, a new 5-year hiring plan was adopted, which focuses on increasing the number of research faculty to 60; giving hiring priority in two of our strongest research groups, Geometric Analysis and Geometric Topology; and expanding applied mathematics. Members of the Geometric Analysis group, including parts of Harmonic Analysis, Mathematical Physics, and Representation Theory have published over 75 papers since 2000, some of which have appeared in first-rank journals including *Annals of Mathematics* and *Inventiones*. Geometric Topology has been a traditional strength at LSU. There are eight faculty engaged in the subject, some of whom graduated in post 2000, yet the group has posted 62 papers on the ArXiv since 2000. as a part of the VIGRE support to the Department. The increasing number of mathematicians has allowed us to give more release time for research. Primarily an applied analysis group, the mathematics of materials science is a highly successful research group led by Robert Lipton. It is well integrated into the Department and is well connected to engineering, physics, and industry. The expansion into computation is led by Susanne C. Brenner who joined the LSU faculty in fall of 2006. The group was initiated in cooperation with the *Center for Computation and Technology* (CCT). The group has now 4 members, two of them with a joint appointment with the Department of Mathematics and CCT. In May 2007, the outcome of a university-wide competition for \$18 million in reoccurring funding was completed. Three interdisciplinary clusters—including computation—were funded. The Department will receive funding for two high-level hires in computation. These will be senior positions split with CCT, which carry a 1-1 teaching load.

The Mathematics Department has a mathematics education group that has a substantial presence in the field. Frank Neubrander and Jim Madden play a leading role in LSU's educational outreach and research center, the *Gordon A. Cain Center for Scientific, Technological, Engineering and Mathematical Literacy* [6]. Frank Neubrander is PI or Co-PI of \$8,000,000 of state and federal education grants. Junior faculty

member Scott Baldridge is the author of widely used teacher education texts (which are used, for example, at University of Michigan, Michigan State University, and Indiana University). Through the *In-Schools Math Labs* project, the Department supports innovation in mathematics programs at selected local middle schools and high schools. A variety of K-12 interface activities are supported through the *MathVision Lab* and the Cain Center. Several Louisiana Systemic Initiatives Program (LaSIP) grants support the design and delivery of in-service professional development for mathematics teachers. The Department is also a leader in precalculus reform and has become known for its results and developments in the *Roadmap to Redesign* (R2R) program (see Redesign and Restructuring on p. 13). The active education program is a resource for the Department, the State, and this proposed VIGRE program.

In addition to support from federal grants, the Department is fortunate to enjoy good state support. Every three-year the Department is eligible to apply for Departmental *Enhancement Grants* from the State Board of Regents. In the last iteration of the Department received grants to support graduate student travel, fellowships for graduate students, a speaker series, research in applied mathematics, equipping the Math Lab, and math education. Also every three years, but on a different cycle from the Departmental Enhancement grants, faculty are eligible to apply for *Research Competitiveness* program. These are general research grants, which are primarily for junior faculty and include travel money and some summer salary.

Faculty are active in interdisciplinary collaborations. In addition to NSF, support for projects comes from Robert Lipton's projects for the Air Force Office of Scientific Research and The Boeing Company. Blaise Bourdin is a Co-PI and Burak Aksoylu is senior personnel on the NSF/IGERT grant *IGERT on Multi-Scale Computations of Fluid Dynamicson computational fluid dynamics*. Other faculty have NSF support from the Division of Computer and Network Systems from the Division of Information and Intelligent Systems. Faculty are engaged in interdisciplinary collaborations with civil and mechanical engineers, biological scientists, computer scientists, and chemists. VIGRE PI G. Ólafsson (LSU Math), L. Butler (LSU Chemistry), and T. Quinto (Tufts Math) organized an interdisciplinary conference on *3-D Image Analysis* that took place at the IMA in January 2006. There were 111 participants from mathematics and the sciences [7].

In addition to our involvement in interdisciplinary and mathematics education activities, we have an energetic faculty involved in the mathematics community. At the January 2007 AMS meeting in New Orleans, fifteen faculty were co-organizers of eleven special sessions, one organized a SIAM minisymposium, one served on the SIAM-JMM coordinating committee, one co-lead the AMS Department Chairs Workshop, and one faculty member participated in an MAA education panel discussion. Five workshops/conferences have taken place or are planned at LSU in the first six months of 2007. The 2003 *AMS Southeastern Sectional meeting* was held at LSU with nine Special Sessions organized by faculty in the Department. The Sectional meeting will again take place at LSU in spring of 2008. The main local organizer is the VIGRE PI Gestur Ólafsson.

In spite of the tremendous difficulties faced by LSU and Louisiana in the wake of Hurricane Katina, the future seems secure for LSU and the Department. In fall 2005, LSU and Baton Rouge became the center of operation for relief efforts following the Hurricane. The basketball arena was converted to the world's largest field hospital. The population of Baton Rouge exploded. In the weeks following Katrina, the Department added over 1000 students to its classes. The mathematical world heard little from LSU. The only travel for the year was from federal money and most visitors had to cancel or reschedule. The number of applications to LSU programs was very low, and the economic future of the University and the State seemed questionable. However, the situation now is quite different. In its recovery efforts, the State has recognized the importance of higher education and an essential role for its flagship university in its future. The governor added a new line to the state budget for LSU's National Flagship Agenda. Applications to our graduate program reached an all-time high. The potential for growth of the Department and the University continues to be strong.

4 The Graduate Program

Graduate Student Support: The Department supports its graduate students with a variety of grant programs and as teaching assistants (TAs). In 2006/07, the Department's graduate students are being paid around \$1.9 million in stipends, of which \$717,000 comes from grants. The recruitment of quality doctoral

students is facilitated by large sustainable resources allocated to the Mathematics Department as one of the University's seven *Foundation of Excellence Programs*. Under this program, Stipend Enhancements, currently \$338,500 per year for mathematics graduate students, have elevated the stipends of most of the Department's doctoral students, with incoming offers averaging more than \$23,000 per academic year. The University has converted terminated instructorship lines into permanent recurring funds for graduate stipends in mathematics. Tuition is no longer charged for Graduate Assistants, and the University is preparing to relieve graduate assistants of most of the cost of health insurance beginning in fall 2007.

The most attractive fellowships that LSU offers is the *Board of Regents Doctoral Fellowship*. These fellowships offer no teaching and a \$30,000 stipend for four years. The Department awarded three of these positions this year. The Department may apply for these fellowships every second year. In addition, students receive support from individual research grants, an NSF/GK-12 grant, and GAANN grants. In Spring 2004 and again in fall 2006, the Department was awarded a three year GAANN grant from the US Department of Education. The funding consists of \$498,132 federal dollars matched by \$124,533 state dollars. These funds are being used to provide 9 doctoral fellowships to US citizens currently enrolled.

Many graduate students are supported as teaching assistants. First-year students tutor, grade, or run Business Calculus question sessions. Graduate students must have 18 hours graduate credit and have completed *Communicating Mathematics* before they can teach a class or an R2R section, see p. 13. Because of precalculus redesign at LSU, graduate students get a wider array of teaching experience. They still teach a calculus class for one year, but they also get experience working with a variety of technology.

The Graduate Student Population: The following table shows the current student population compared to the student population in 2000, just after we submitted our first VIGRE proposal. More information is provided in the Appendix.

GRADUATE STUDENTS: GENDER, MINORITY AND CITIZENSHIP							
Year	Number	Female	%	Minority	%	US citizens	%
Dec. 2006	94	26	27.7%	9	9.5%	46	48.9%
2000	53	16	30.2%	4	7.5%	24	45.3%
Increase	77%	63%	-2.5%	125%	+2%	92%	+3.6%

In spring semester 2006/07 the Department had 88 graduate students. Of those 27 were first-year students. As of May 2007, 58 have passed their PhD qualifying exam and 28 of those are US citizens. The gender distribution among the international students is 29 male and 13 female students. At the moment there are 2 black US students, 2 Hispanic students and one Asian US citizen. Of the first year students, 7 are female and 3 of them are US citizens.

The Department has a solid record of recruiting strong doctoral students. In spring 2007 the Department received 172 applications for graduate study. Of those, 53 were US citizens. The American applicants averaged above a 3.5 undergraduate GPA and above 3.6 graduate GPA (if applicable) on a 4 point grading scale. The Department recruited 12 new doctoral students, making a total of 29 offers.

During the period 2000-2006 the Department's African-American and Hispanic-American PhD graduates comprised 8.8% of its 45 PhD graduates. According to the 2002 Annual Survey of the Mathematical Sciences [9] only 2.1% of PhD graduates in the entire US in Mathematics belonged to these groups. *Thus the Mathematics Department graduated minority PhDs at more than four times the national rate.* During the same period, 27% of the Department's PhD graduates were women. For example, Norma Ortiz (PhD 2005) was a Hispanic-American *Louisiana resident*, now a tenure-track assistant professor at Virginia Commonwealth University. Uroyoan Walker (PhD 2001) and Gary Salazar (PhD 2000) are Hispanic-American men: Walker is an associate professor at the University of Puerto Rico and Salazar is a visiting assistant professor at Trinity University in San Antonio. Sam Nelson (PhD 2002) held visiting assistant professor positions at the University of California at Riverside and at Whittier College (which he does presently). Said Ngobi (PhD 2000) is an African US permanent resident and is tenure track at Alabama State University, and Jamiiru Luttamaguzi (PhD 2002) is an African US permanent resident and is tenure-track at Elizabeth City State University, NC.

Graduate Student Placement: Of the 46 PhD graduates in mathematics from August 2000–August 2006, 19 were US citizens, 12 were women, and 4 were African or Hispanic-American. Of our graduates, 43 took postdoctoral or tenure-track jobs and three entered industry or the Defense Department. The postdoctoral positions held included jobs at Max Planck in Bonn; McMaster University; Queens University, Ontario; University of Paderborn, Germany; University of Iowa; University of California Riverside; and University of Utah. In 2004, our 1996 alumnus, Yongdo Lim, won a prize from the Korean Mathematics Society for the best research paper of the year by a Korean mathematician.

Several faculty have put in effort to make opportunities available for graduate and undergraduate students to take internships to broadening their education and experience. Our graduate student Tim Breitzman took an internship at Wright Patterson Airbase, followed by a regular semester internship. Now he is a Senior Scientist permanently employed there. Simone Flory and Fabiana Cardetti, interned one summer in Baton Rouge with Innovative Emergency Management modeling plumes of toxic gases in the atmosphere. Fabiana Cardetti took a postdoctoral position at University of Connecticut and is now in a tenure-track position there. Simone Flory went into private industry and is now Vice President of Risk Review at *Wells Fargo & Co.*

The facts above demonstrate that the LSU Mathematics Department has the ability to recruit high quality graduate students internationally as well as nationally and regionally. The resources mobilized in recent years have greatly increased our ability to draw in excellent US students. We produce graduate students well-qualified for research positions, but we are also aware of the problem we have at placing our graduates in postdoctoral or tenure-track positions at group I and II universities. The problem is often based on cultural or family reasons. For example, Jeremy Becnel who had 4 complete papers prior to graduation with two accepted in *The Proceedings of the American Mathematical Society*, decided to forgo applying for research postdocs, and took an early tenure-track job at Stephen F. Austin University. Nevertheless, the placement of our students into colleges also has a substantial effect in accomplishing the goals of VIGRE. For example, two years ago a student, Bill Schellhorn, was shortlisted for postdoctoral positions at Michigan State and Iowa. He withdrew and took a job with his wife (who was also graduating from our Department) at Simpson College in Iowa. This year he attended the national AMS-MAA meeting in New Orleans and accompanied three of his students who were making undergraduate research presentations at the meeting. Some of this phenomenon is likely due to the fact that we do recruit talented students from rural locations and small colleges who wish to return to this environment. However, the Department would like to transform the graduate culture to encourage students to take research postdocs.

The Department recently took steps towards addressing emphasis on research and academic achievement (beyond mentoring by the dissertation advisor) to counterbalance the teacher preparation and teaching awards that accumulated over the last decade: (1) An annual group mentoring meeting was initiated in fall 2006. This took the form of a panel discussion and involved some of our young faculty; (2) We funded two new graduate student awards: *The Porcelli Award for Research Excellence* and *The Porcelli Award for Academic Excellence*; (3) We are also instituting a warm-up program to inculcate students into the mathematical culture upon entering graduate study: GEAUX Math@LSU (see p. 10). Addressing the challenge of making this cultural change is a goal of this VIGRE proposal.

In fall 2006 the Department organized (the first of an annual) panel discussion of faculty members, which included five faculty with one from applied mathematics and two assistant professors who had postdoctoral experience. The main topic was how to prepare for a successful job application. The discussion included steps to take during the graduate career to be in a position to succeed. The Department has introduced a Postdoctoral Job Application Resource Center [4] which includes advice for preparing a vita, submitting a research paper to a journal, and writing a Research Statement and a Statement of Teaching Philosophy. There will be case histories showing how past students succeeded in their job searches.

Graduate Student Day: For the past six years, the Department has organized a *Graduate Student Picnic and Orientation Conference* at the beginning of the fall semester, to welcome new and returning graduate students to the new academic year. During this social and educational event faculty members from the research groups give survey talks about research opportunities for graduate students. *In fall 2006 we included two graduate students as speakers.* Graduate student Jens Christensen presented a talk about harmonic

analysis, and he gave advice to new graduate students about how to deal with challenges they will face. An African-American GAANN fellow, Gideon Daspan, spoke on his research on the KP equation.

Graduate Curriculum: Each semester, the Department provides approximately 14–17 traditional graduate courses, and an average of 30 individual reading courses and doctoral research sections. For fall 2007, 17 courses are slated to be taught, but a course must attract 5 students or auditors. Courses offered are divided into three categories as described in the *Outcome of Curriculum Review* section. The last three semesters faculty members have also run a *Deep Reading Seminars*. The Deep Reading Seminar in Harmonic Analysis was offered by VIGRE PI Gestur Ólafsson during the spring semester 2006. The students studied the work by Carlos Berenstein and David Walnut on the local inversion of the Radon transform using wavelets. Most of the talks were 90 minutes divided over two weeks. Each of the students had to write the talk in Latex and show it to the advisor at least one week before the presentation. A Combinatorics Deep Reading Seminar took place during the fall 2006 and was directed by Dirk Vertigan. Six students participated in reading the book *Integer Flows and Cycle Covers of Graphs* by Cun-Quan Zhang. The seminar had one 90-minute meeting per week throughout the Fall 2006 Semester. In a similar direction, the *Junior Topology Seminar* organized by Oliver Dasbach, has 8 students. Graduate students talk about their research or topics of their interests. The seminar will continue during the summer. The Junior Topology Seminar is not a credit course.

Each student must pass an 11-hour battery of written PhD Qualifying Exams by January of the second year of study. Students must have each semester's course selection approved by their *Advisory Committee*. Every student is required to pass an oral General Exam for the PhD by the end of the third year as a condition of receiving financial aid. This exam is conducted by the *Advisory Committee*, which is chaired by the student's dissertation advisor and includes at least four additional Department faculty members, together with a Dean's Representative appointed from another department at LSU.

Each research group runs a weekly research seminar, involving both faculty members and graduate students. It is common for graduate students to present results from their dissertation research or other topics of interest.

The Research Connections Program: The Department encourages its students to visit other departments and universities during their study. For the last five years and continuing at least through spring 2008, the Department has had Board of Regents grants to cover international travel and expenses for graduate students to make extended visits. VIGRE senior personnel Robert Perlis has been the PI for these two travel grants. Through this program, 22 graduate students have made trips of a month or more to participate in special research semesters, conferences, or university consultations. On the most recent grant, students visited Amsterdam, Darmstadt, Innsbruck, Lausanne, Madrid, Moscow, Novi Sad, Paris, Sydney, Utrecht, Valladolid and Vienna. The Research Connections Program also complements benefits available to LSU graduate students through the Mathematical Sciences Research Institute (MSRI). As an academic sponsor, LSU sends advanced students to graduate programs organized by MSRI.

Communication skills: During the first year, in addition to the core classes in mathematics, all graduate students are required to participate in the *Communicating Mathematics* course. About half of the course focuses on the teaching of mathematics. Students are required to observe the classes of an assigned experienced mentor, to complete questionnaires on these observations, and to present mini-lectures, first before their graduate peers, and then before their mentor's undergraduate class. These presentations serve as focal points for in-class discussions of a broad range of pedagogical issues. The other half of the course concentrates on expository issues. Each student is required to write a short survey paper in LaTeX, prepared under the supervision of a faculty member. Students present a 15-minute talk on this paper to the class and interested faculty organized in short special sessions. After each special session the students discuss the presentations. This project enables the graduate students to meet more faculty members than they would see in their lecture courses. The talks are presented in conference-style sessions with the speaker using overhead transparencies or a computer-based slide presentation. This course introduces students to the tools needed for clear and effective communication of mathematical ideas.

Beyond the first year, students get experience speaking in seminars and, later in their program, at conferences. Many faculty believe that our students do well in conference presentations compared to their peers and it is due to their early training.

GEAUX Math@LSU: The new warm-up program *Graduate Education and Acclimation to the University eXperience* or GEAUX Math@LSU, is a two week educational and social gathering for incoming graduate students to prepare them for their study at LSU as well as their duties as Teaching Assistants. A committee of five graduate students Rick Barnard (3rd year), Leah Childers (2nd year), Moshe Cohen (3rd year), Susanna Dann (3rd year) and Amber Russell (1st year) have been working on the planning. The idea was initiated by observing the University of Chicago *WOMP* program [10]. The basic goals of GEAUX Math@LSU, which are all strongly related to the basic goals of the VIGRE program, are to: train graduate students in planning and decision making; give senior graduate students the opportunity to develop and present advanced mathematical material; integrate the incoming students into the departmental life; begin to inculcate students into the mathematical culture; provide a bridge from undergraduate curricula to the challenging first-year graduate core program; and begin peer mentoring among graduate students.

The program will take place during two weeks prior to the start of fall classes. There will be several lectures on Point-Set Topology, Algebra, and Analysis, as well as enrichment talks to preview advance material. There will also be social events at LSU and downtown, a tour of the LSU campus as well as university orientation and orientation for international students. TA training and the technical aspects of the computer systems will be included. Further information can be found at [11]

5 The Undergraduate program

As the state flagship university, LSU attracts many of the top students in Louisiana and the southern region. One substantial economic incentive for strong Louisiana students to attend LSU is the *Tuition Opportunity Scholarship Program (TOPS)* [12]. It provides scholarships equal to college tuition for high school graduates, and, since LSU's entry requirements are higher than TOPS requirements, almost every Louisiana freshman admitted to the LSU receives a TOPS state-funded merit scholarship. Exceptional in state or out-of-state students may receive competitive awards, such as *Chancellor's Alumni Scholarship*, *LSU Alumni Association Top 100 Scholarship*, or the *Distinguished Freshmen Award*. Recipients of any of those scholarships and awards as well as the *National Merit Finalists*, the *National Achievement Finalists* (designated as Louisiana residents), or the *National Hispanic Scholars* (designated as Louisiana residents) are eligible for the *Chancellor's Future Leaders in Research program* [13], which awards a \$1,500 stipend for undergraduate research experience with a faculty mentor. Several of the *Chancellor's Future Leaders in Research* students have worked with members of the Department. Also, the Department always has its share of strong students. Last year Nickolas VanMeter a senior mathematics major won a prestigious Goldwater Scholarship, and this year our Putnam Competition team finished 21st in the country (out of over 400 participating teams).

Undergraduate students in mathematics can also apply for the *Louisiana Science, Technology, Engineering, and Mathematics (LA-STEM)* Research Scholars Program [14] valued at approximately \$9,500 for the academic year in addition to paid participation in the *Office of Strategic Initiatives's* Summer Bridge Program.

New Concentrations: The number of mathematics majors has increased by 148% in the last 5 years (see the two tables on p. 3). Foremost among the causes of this increase was the expansion of our system of concentrations, which act as a magnet for strong students to pursue mathematics. Few Louisiana high school graduates enter college with the ultimate goal of graduate study in mathematics or any advanced degree. Students and parents do not see a clear path to employment in mathematics as they do in engineering and the sciences. The new concentrations have made students aware of some of the possibilities and once in the mathematics, a student can easily change concentrations or change career goals. For example, last year one of our secondary education concentration majors, John Tate, finished in this concentration and decided to attend graduate school in mathematics at the University of Utah. This year another student, Daniel Hotard who graduated Summa Cum Laude in our secondary education concentration will pursue his PhD in mathematics at LSU.

The Actuarial Science concentration began in 2000 and has been very successful. It has a steady enrollment and an associated student organization: The Actuarial Student Association (ASA) [15]. The ASA

organizes student study for the required exams and invites outside speakers. The Baton Rouge location of Blue Cross/Blue Shield has offered and continues to offer internships to our students. Other students have obtained internships in other parts of the country. Recent graduates have taken jobs at Pan American Insurance, CIGNA, and Mercer.

In 2003, we began a new concentration in Secondary Education, based on the urgent need of qualified mathematics teachers in Louisiana and coordinated with broader changes in teacher education and certification in Louisiana. The State's *Blue Ribbon Commission on Teacher Quality* created undergraduate secondary program guidelines that would produce teachers certified in both a primary and a secondary content area [16]. LSU faculty with strong involvement of the Department of Mathematics, sought additional undergraduate routes that might later serve as a model for consideration by all of the State's IHEs. The result was a plan, called *Geaux Teach* [17], for degree and certification programs offered through the content-area colleges in close partnership with the College of Education. The program has been supported by NSF STEMTP and NSF Noyce Fellowship grants.

In 2007/08 a new concentration in Mathematical Statistics will begin [18]. This concentration was formed in partnership with the department of Experimental Statistics, which does not have an undergraduate major. Students will be well prepared to enter graduate school in statistics or enter directly into the workforce. We expect it to have a substantial impact on the number of our majors. Also the under-subscribed concentration Communication Engineering will be discontinued.

Capstone Experiences: One of the major new initiatives following the 1999 external review was the introduction of capstone courses. The initial capstone course, Math 4020, was an offering through the Mathematics Consultation Clinic, which is a vertically integrated industrial mathematics problem solving clinic. Under the direction of a faculty member—usually Peter Wolenski—a PhD engineer, mathematics graduate students, and undergraduates, work on interdisciplinary problem often brought from industry. Dr. Wolenski has had his course certified as a Communication-Intensive by the university program *Communication Across the Curriculum* [19]. This course often provides Mathematics majors with their first opportunity to work on serious collaborative mathematical work. The course concludes with open presentations and a poster session. Spring 2007 projects included joint collaborations with William Olefins Company and the Kinesiology and Civil Engineering Departments at LSU (see Outreach Programs on p. 12). Two other capstone opportunities have been added recently: One for the Secondary Education concentration, Math 4004, and one in statistics, Exst 4087, for the Mathematical Statistics and Actuarial Science concentrations. In addition, we now allow students to substitute a topics course if they have participated in a summer NSF/REU program. Other capstone experiences may be individual undergraduate research projects. We would like to expand the variety of opportunities using the proposed VIGRE crew structures (see p. 13).

Gateway Courses: The Department instituted three sophomore-level gateway courses to promote recruitment of majors and to facilitate the transition to higher-level mathematics. Students are introduced to rigorous proofs in content-based courses. The gateway courses are: *2020 Discrete Mathematics with Combinatorics*: Logic, counting, discrete probability, graph theory, and number theory; *2025 Wavelets Made Easy*: Introduction to mathematical proofs and structures using selected topics from analysis and linear algebra; vector spaces, wavelets, applications, and the Fast Fourier Transform if there is time; *2030 Discrete Dynamical Systems*: Dynamical systems with discrete time and in one spatial dimension; hyperbolicity; quadratic maps; chaos; structural stability; bifurcation theory; and higher dimensional systems.

Extensive Advising: An important change in the mentoring and guidance of our undergraduate majors is the institution of an extensive system of undergraduate advising. All mathematics majors must meet with an undergraduate mathematics faculty advisor each semester. Both students and faculty have found this to be beneficial. Faculty are more in touch with the students, and students benefit from the increased familiarity and are more comfortable seeking guidance. Currently 13 professors serve as undergraduate advisors.

Graduate-School-Bound Students: To better prepare students for graduate study the Department made a philosophical change and curriculum changes. The three-course sequence in Advanced Calculus, Math 4031-2-5, is now our undergraduate sequence in analysis for preparation for graduate school. In addition, graduate school-bound students are advised to take 3 semesters of algebra (Math 4153: Finite Dimensional Vector Spaces, Math 4200: Abstract Algebra I, and Math 4201: Abstract Algebra II, which is Galois Theory), and

1 semester of Topology. The philosophical change was to make our program more rigorous and to encourage advanced students to begin our graduate sequence of courses. The determination of appropriate placement of students combines well with our more extensive system of advising. Another rigorous proof-theoretic advanced course that was recently added is Math 4058: Elementary Stochastic Processes. Students take it as a sequel to Math 3355: Probability. It is required for the Actuarial Concentration and expected to be popular among the Mathematical Statistics students. Our Actuarial Science students are legitimate mathematics majors and need relevant proof-oriented courses. Some Actuarial students pursue advanced study (*e.g.*, Wei Wang pursued graduate study in Financial Engineering at Cornell University). Both new courses have healthy enrollments. Other recent changes include a short after-hours course to help prepare students for the GRE subject area exam in mathematics (offered by Mark Davidson). This year Pramod Achar helped several talented students with preparation of NSF Graduate Fellowship grant applications. We have also increased the use of graduate students to support our proof-oriented and gateway courses.

Undergraduate Research: Many faculty direct individual undergraduate research projects. Students have conducted research projects as part of the Chancellor's Future Leaders in Research program, NSF programs (*e.g.*, CSEMS scholars) the McNair program, individual faculty NSF research grants, CCT projects, and honors thesis projects. This work is in addition to the projects conducted in the organized Mathematics Consultation Clinic. We have conducted approximately 20 such projects in the last two years. They have included such topics as Rotating Black Holes, Elliptic Curves, Knot Theory, and Mathematics of Materials. Elena Caraba who did an undergraduate research project with a joint math/CCT postdoctoral associate H. Beyer, has an internship this summer at the Lawrence Berkeley National Laboratory. Undergraduate honors theses are generally for one or two semesters. For example, Jacek Cygan is now guiding D. Guillot, who also has a music advisor, on a thesis on *Wavelets and Music*. Another student, Matthew Arnold, is writing an honors thesis with Dan Sage on *Random walks on groups—applications of representation theory in probability*.

Other Resources: The University also offers resources that benefit undergraduates directly. *Career Services* offers students aid in writing a resume and interviewing [20]. The mathematics contact person from Career Services speaks to the Math Club and the Actuarial Student Association one or twice a year (but they will come as often as requested). They work with individual students on their resume and interviewing skills. Another resource is the *Center for Academic Success*, which was named the 2004-2005 Outstanding Learning Center in the Nation by the National College Learning Center Association. They have assisted our NSF/CSEMS and will assist our NSF/S-STEM by offering individual and group-study strategy sessions for the scholarship recipients to teach the students how to maximize their learning potential.

REU programs: For the past 12 years LSU has continuously run a two-month summer Math REU funded by NSF and Louisiana Board of Regents. The students come from across the US with many students from elite east- and west-coast institutions. Others participants are highly recommended students from non-elite universities. These students are competitive with those from better-known schools but often have taken fewer theorem-proving courses. The REU program is directed by LSU mathematics faculty and involve graduate students as well. They have been highly successful and 7 of the participating students decided to do their graduate study at LSU. Topics vary, but recent topics include investigations of braid groups, finitely presented groups, and zeta functions associated to graphs. In several cases, REU project work has led to substantial exposure in the mathematical community for program participants.

Outreach Programs: The Department operates a highly successful industrial and educational outreach program, the *Mathematics Consultation Clinic*. Recent clients include CII Carbon, a chemical company based in New Orleans, Innovative Emergency Management, Inc., a software developer based in Baton Rouge, Hibernia National Bank, the Louisiana State Lottery Commission, and Our Lady of the Lake Hospital. Several summer internships have resulted from this work. See also Capstone Experience on p. 11.

The *MathVision Laboratory* [21] is a relatively new educational outreach unit of the LSU Department of Mathematics that implements education-research based programs. MathVision activities are designed to support and accelerate the positive educational changes made in our state during the last six years. The Lab has ongoing projects with the LSU Colleges of Basic Sciences, Engineering, and Education, with Southeastern Louisiana University, Southern University Baton Rouge, LSU Shreveport, New Mexico State University, UT

Austin, with the Louisiana Resource Center for Educators, and with the East Baton Rouge, Livingston and Tangipahoa Parish school districts. Many mathematics, science, and engineering undergraduates and graduate students provide tutoring in local schools as part of the MathVision activities.

The *LSU Mathematics Contest for high school students* [22] is a math contest that is held on a Saturday each March. It was started by Co-PI Larry Smolinsky in 2002. It attracts high schools from around the state of Louisiana and has also attracted schools from Alabama, Texas, and Oklahoma. There is usually participation from 200 to 300 students. There are trophies and small cash prizes for nine students who win the major exams, books as prizes for the best scorers from each participating high school as well as for the teachers, and a large number of certificates are awarded. Medals are given to 3 teams of students who win the afternoon team competition. During the long morning exam, there is a reception for the high school teachers and LSU faculty members. The reception is a chance for us to meet with teachers from some of the best high schools from around the state.

The *Math Tune-Up* [23] is a summer program run by the Department for incoming graduate students in science and engineering. The program has been funded by Board of Regents grants, and now receives support from the College of Arts and Sciences and the Graduate School.

Redesign and Restructuring: As a part of the restructuring of the Department and reducing the number of instructors, the Department reevaluated the assignments and workload in precalculus classes and began a plan to teach its precalculus, Business Calculus, and general education courses in a more efficient and effective manner. In the most educationally significant change in this direction, the Department became part of the national redesign movement. We joined the *National Center for Academic Transformation's* US Dept. of Education FIPSE grant the *Roadmap to Redesign* (R2R) [24, 25]. LSU was the largest redesign in R2R and has had great success [26]. The Department is very active in design, assessment, and dissemination of the methodology. The model is designed to incorporate technology in an integrated cost effective manner rather than as an add on. The students have one hour meeting in a small group with their instructor each week but otherwise they work in a computer lab, where instructors, TAs and other graduate students, and undergraduate tutors are available to help. Over \$1.1 million was invested through University, student, and grant funds to build the showcase Mathematics Lab to support the program. The resources from the overall restructuring were used to expand the research faculty, which put more resources into research, the graduate program, and the undergraduate major. Many of the changes and additions described in the undergraduate and graduate sections are made possible by these personnel resources.

6 New Initiatives through the VIGRE program

The Department is proposing new initiatives to integrate graduates and undergraduates to research early, to enhance the scientific education and professional development of our students, and to enhance vertical and horizontal integration of research, education and outreach. To see successful VIGRE programs in action, the PI and the Department chair, Co-PI Larry Smolinsky, visited the University of Arizona, the University of Chicago, the University of Georgia, and the University of Utah. They met with faculty members and students and observed various VIGRE program elements. Knowledge gained from these visits is incorporated into this proposal. The proposed new activities are closely tied to existing structures and initiatives and consideration of previous VIGRE reviewers' comments.

6.1 The Research Crews

The Research Crews will be our main vehicle for vertical integration of research and education. The research crew structure may be considered to be an analog to a research/teaching laboratory in the sciences. The scientists and students working on a laboratory project are engaged in a coherent study, but each participant makes contributions. Mathematicians do not have laboratories, but we engage in research projects and study topics that have many aspects. Each crew will consist of faculty members, postdoctoral associates, graduate students and undergraduate students. It will be a piece of educational and intellectual infrastructure that may serve both education and research. The crew structure has been proposed in previous LSU VIGRE

proposals but has grown into a more significant concept. It has developed from REU structures and best practices from the *University of Georgia* VIGRE groups [27]. Our Mathematics Consultation Clinic is a virtual industrial VIGRE crew (see Capstone Experience p. 11 and Outreach on p. 12).

The term *Research Crew* is used both to describe the individuals who work together in the education/research structure and an actual course through which the opportunities are offered. The goal of a crew will be to provide directed research opportunities for the junior members, mentored by the senior members, and incorporating participation and professional development for all involved. One faculty member will be the crew leader. Crews should engage in an overall coherent study, but subgroups may be engaged in different ways. For example, some or all of the members may be working on original mathematical research that may result in the publication of a paper, but other contributions are possible. Some students may work on examples and computations. Other students may be independently reading and assimilating a paper for presentation to the whole group. Students should be involved in creative mathematics and prepare written reports and make mathematical presentations to the whole crew. Students may be broken into small groups with a faculty advisor that work on specific aspects of a problem and then present the results to the full group and point out further directions. Smaller groups may meet several times during the week. New goals and tasks may be formulated through discussion. The crew leader will need to monitor that all students are involved in a meaningful way. The crew structure will be valuable infrastructure to:

- 1) The undergraduate program. It will give undergraduates a wider choice of research experiences. It will be a framework to support the LSU Honors program, NSF S-STEM scholars, and other programs requiring research experiences. A transparent manner to obtain research experience in mathematics should attract more mathematics majors. Students may register for capstone experience. (Please see Undergraduate Research Apprenticeships on p. 16.)
- 2) The graduate program. To encourage students' interest in research, it would be desirable to introduce students to research opportunities early. The VIGRE crew may also give graduate students the opportunity to interact and mentor higher-level students than in the past.
- 3) Research groups. Crews will be attractive for research groups because the crew will be a course that carries teaching credit for the crew leader, the formation and dynamic continuation of crews *will be a primary consideration in the hiring of postdoctoral associates*, and research areas that have crews will have a tremendous vehicle for attracting students into the field.
- 4) Attracting funding for scholarship programs. NSF, State, and university scholarship programs require rich professional development. The crew structure will give mathematics a vehicle to compete with science training on a more level playing field. These scholarship programs are usually geared toward minorities, economically disadvantaged, or extremely talented students—desirable target students for mathematics.

Faculty proposals will be submitted to the VIGRE steering committee. The PIs will choose will choose crews in consultation with the VIGRE steering committee, the hiring committee and the graduate director. We believe that crews must be flexible to motivate faculty to participate and try new ideas. A Research Crew may be proposed by one of our standard research groups or it may be proposed by a cross section of faculty, *e.g.*, a crew on quantum field theory may involve interested faculty and students from all areas. We expect that one of the crews will be in applied mathematics/computation.

VIGRE supported Doctoral Dissertation trainees (see p. 16). Board of regents and GAANN fellows will be required to participate in their second and third year. The first year VIGRE students will be required to take one extra course in their second semester, which may be a crew.

6.2 Research Connections Program

VIGRE will enhance the Research Connections Program, (see p. 9). Graduate students can spend a month during the summer or even a term on-site at a national or local laboratory or an industrial or academic institution broadening their horizons and gaining experience that may be valuable after graduation. The Center for Bioinformatics at Colorado State University, Center for Advanced Microstructures and Devices (CAMD), and the LSU Department of Chemistry have agreed to support the VIGRE proposal by incorpo-

rating LSU mathematics students into their projects. We are also investigating forming relationships with *NASA-Stennis Space Center* in Mississippi and the *The Pennington Center for Biomedical Research* in Baton Rouge. Exposure and experience in working in applied mathematics and applications provide valuable professional development for graduate students. This is an often neglected part of professional development, which is largely directed toward teaching. Students observe the academic system and develop comfort in it, but an internship experience can give a measure of familiarity and comfort and make them open to the possibility of industrial research. According to NSF representatives at the AMS meeting in New Orleans, VIGRE was motivated by the shortage of mathematicians. While there is not an acute shortage of mathematicians seeking university jobs, there is for industry jobs. Students will likely consider the most desirable jobs to be prestigious academic positions, but for the next level of position they should be prepared to choose between industrial research or college teaching.

In addition to providing internship opportunities, this program will bring mathematicians to LSU from industry and national labs to speak to students about their work and employment opportunities. LSU has a rich tradition of graduates, who have risen to prominent positions in industry.

6.3 The Postdoctoral Program

An active department needs a continuous influx of new ideas, methods, and problems. An effective postdoctoral program, visiting faculty positions, and frequent hiring of new assistant professors all contribute to the achievement of this objective. The Department has been fortunate to have a large influx of junior faculty, but we have also had a emerging postdoctoral program that has developed since 2000. The Department had two Postdoctoral Researchers in 2000-2001, three in 2001-2002, and three in the years 2002-2006, all but one supported with the help of CCT. We have five postdocs in 2006/07: three supported by CCT, one supported from a research grant, and one fully in mathematics. In these years, the Department also had a number of shorter term visitors. Two of the current postdocs are US citizens, and one of them is a minority. A list of visitors and postdoctoral associates may be found in the appendix.

With one exception the Postdoctoral Researchers were hired for terms of at least two years and had a 1-1 teaching load. The one exception is Michael Stuebner, who was an LSU student supported as 100% research for one year after his graduation on his advisor's grant. He is an applied mathematician and will be a research postdoc at North Carolina State University.

CCT has also began a program called the *Distinguished Postdoctoral Fellow in Computational Sciences Program* [28]. The year 2006 was the first year of competition and VIGRE PI Susanne Brenner will have a postdoctoral associate in the program.

As part of the LSU commitment to VIGRE, CCT has agreed to continue to support the Department with postdoctoral associates during the first three years of the grant. As before, CCT postdoctoral associates will be affiliated with both the Department of Mathematics and CCT. Furthermore, the *College of Arts and Sciences* has committed half support for *four positions for the duration of the VIGRE grant*. The University committed that ***four permanent postdoctoral positions will be added to the Mathematics Department as part of the VIGRE grant commitment***. These positions are not tied to CCT. This addition will be a tremendous boon to the Department giving us the permanent postdoctoral program that the department faculty has long desired.

It is planned that each position will be for an initial appointment of two years with a possible extension of one more year. Each postdoctoral associate will be a member of a research crew and play a prominent role in its research and educational efforts. All postdoctoral associates will benefit from a teaching load of six hours per year. Part of this teaching may take the form of special educational activities of the research crew. In addition, postdoctoral associates will gain experience by serving as mentors for graduate and undergraduate students supported by the VIGRE program.

6.4 Traineeships

To attract new students and enhance the training of its American students, the Department of Mathematics proposes to use the VIGRE grant to create three new types of graduate traineeships for US citizens. We plan

to fill a total of 9 traineeships each year. These are the *Doctoral Foundation Traineeship* (DFT), *Doctoral Dissertation Traineeship* (DDT), and the *Dissertation-Year Traineeship* (DYT). To obtain a VIGRE support a continuing student will have to submit a *short proposal* to the VIGRE committee describing their goals and activity during the time of support. The proposal should state the beginning and ending period for the support, in which *research crew* the trainee will participate, and his or her research and learning goals during the period. The proposal should include a statement about planned interdisciplinary work or internships as well as expected interaction with undergraduate students. Finally, the proposal should include a CV that contains a statement about previous participation in VIGRE activities. If travel or expenses other than participant support is involved, then a budget is also required.

The duration of each traineeship is not fixed. It may be up to 11 months with a possible 11-month extension. It may also be restricted to one semester or summer support. The maximum combined traineeship support is 33 months. The stipend will be up to \$25,000 per calendar year, and may be supplemented by \$3,000, \$5,000, or \$8,000 in university enhancement/supplement funds awarded by the Graduate School to deserving applicants nominated by the Department. The maximum amount of traineeship support and supplement is \$30,000 as it is with the Board of Regents Doctoral Fellowships and the GAANN Doctoral Fellowships.

Doctoral Foundation Traineeships: One important objective of the VIGRE Program is to recruit promising young American doctoral students. To this end, the Department will offer DFTs to rigorously selected US citizens who are not already enrolled in the graduate program at LSU. Special attention will be paid to underrepresented groups. The initial duration is 11 months, but the trainee can submit a request for an extension to maximal 11 more months. The purpose of these traineeships will be to support exceptionally promising doctoral students in their initial study at LSU with no duties required other than those that enhance the professional preparation of the student. It will free the student's time and energy for the effort of bridging the gap between undergraduate and graduate study, and to begin forming a solid foundation for a career in mathematical research. The trainees will have to take *one extra course* in the second semester. This course can be a *research crew* or one of the core-two courses.

The Doctoral Dissertation Traineeships: DDTs may be offered to doctoral students who have started research work with an advisor who will have to submit a strong written recommendation. Prior participation in a research crew will be considered positively by the VIGRE committee in its decision.

Students who have been supported by the *DFT* are expected to have teaching duties before they can apply for a DDT Traineeship.

Dissertation Trainees will have no regular teaching duties, but their activities during the traineeship period is expected to contain interaction with undergraduate students and/or professional development. This can consist of mentoring and participating in crews, mentoring undergraduate students, helping with extended computer lab work, assisting in the Mathematics Consultation Clinic and the VIGRE REU, the GEAUX Math@LSU warm-up or the appropriate K-12 outreach projects.

The Dissertation-Year Traineeships: DYT will be offered to students who have already had *at least one year* of teaching experience at LSU and are strongly expected to complete the doctoral dissertation during the one year of such support.

To apply for the stipend the student must submit to the VIGRE committee the material stated in the beginning of this subsection as well as a letter from the chair of the advisory committee. This letter must provide convincing evidence that the doctoral dissertation will be completed successfully during the proposed year of support. A student who has received a Dissertation-Year Traineeship is not eligible for any further support from VIGRE funds in case he or she is not able to carry out the plan to complete the dissertation successfully in one year.

Undergraduate Research Apprenticeships: The VIGRE crews will span all academic levels from faculty to undergraduates. As mentioned earlier, LSU mathematics undergraduates participate in a number of programs that can benefit from VIGRE. Undergraduates have long contributed to laboratory work. However, the inclusion of mathematics students in research-like activity is neither as easy nor as natural as in the sciences. The VIGRE crew structure can radically change the situation by being a virtual laboratory run by the crew leaders. We expect the honors program to benefit. Each student is a major undertaking for

a faculty member who is directing the undergraduate's work. With the VIGRE crew infrastructure, some of the burden of directing an honors student will be institutionalized so that it may be easier for a student to approach and obtain an advisor. Students will have more choices as well since they may choose from multiple VIGRE crews. The opportunity for students to participate will make it possible for mathematics to handle more students and it will attract students too. Sufficient participation of undergraduates in the crews will also make it likely that these crews can be turned into courses for the long run continuation of the program. The model for incorporation of the undergraduates comes from two sources: best practices of our own vertically integrated LSU Mathematics Consultation Clinic and the University of Georgia VIGRE groups, which has successfully included undergraduates.

6.5 Seminars and the Student Colloquium

The Department has for several years run a *Graduate Student Seminar*, organized by the graduate students themselves. The speakers are mainly graduate students that are close to graduation. On the undergraduate level there is the *Math Club*, now advised by Michael Malisoff; the *Student Actuarial Society*, advised by Larry Smolinsky; and Susanne Brenner is presently organizing a student chapter of SIAM [15, 29]. The Math Club is an organization of undergraduate students who promote and engage in activities of mathematical interest. Meetings usually consist of refreshments and a mathematical talk by an invited speaker, frequently by one or more professors or graduate students from LSU. There are typically around 7-10 meetings per semester.

To enhance the interaction between undergraduate and graduate students, we plan to upgrade the *Graduate Student Seminar* to a *Student Colloquium*, which will include senior undergraduate students. But being aware of the fact, that the interests between graduate and undergraduate students might be different, we will monitor the Student Colloquium closely.

We intend to invite around 8 selected speakers each year to stay at LSU for at least 3 days to interact with students and faculty. In some cases the speaker may give *two* talks, one more advanced in the *Student Colloquium* and another, more geared towards undergraduate students, in the *Math Club*.

The colloquium would be organized by graduate students: They find the speakers, contact them, organize the travel. One faculty member will act as a mentor and advisor.

6.6 The VIGRE Summer Program

The VIGRE summer program will be an opportunity to broaden the graduate and undergraduate students' background and perspective. The operation of the summer program will be an adaptation of the best practices from the University of Chicago model: Undergraduate students will undergo training and interact with high schools students and high school teachers on substantive mathematics. The undergraduate students are challenged to be clear and understandable in their explanations. They will develop their communication skills and deepen their mathematical knowledge. In addition, the program will incorporate an important idea from the University of Arizona: To interact with nearby universities and colleges, both on the level of students and advisors.

Undergraduate students will participate from a consortium of schools and so the impact will reach beyond LSU. The LSU department chair has discussed and received verbal agreement from the chairs of the mathematics departments at the *University of Mississippi*, *University of South Alabama*, *Mississippi State University*, *University of Louisiana at Lafayette*, *Southern University*, *Grambling State University*, and *University of New Orleans*. In addition we plan to invite the *University of Alabama*, *Southeastern Louisiana University*, and *Xavier University of Louisiana*. We did not request letters since there is no financial obligation from the participating schools. The list includes major state schools and three historically black schools (including Southern University, which is the largest in the US). We leave open the possibility of expanding the consortium.

A VIGRE REU will have research topics chosen to align with faculty lecture topics. The projects will be arranged by the faculty members. Projects will be primarily directed by graduate students. Invitations for students from consortium schools will be on the MSRI model: Each consortium school will be allowed

to send one student and an additional student if that student is a woman or underrepresented minority. At the conclusion of the VIGRE REU, students will conduct a poster session that will be open to the faculty, participants in our national NSF REU, students, and the public. The VIGRE REU will be a 5-week program coinciding with the LSU summer schedule. The mentors will be two faculty members from LSU and two from the consortium schools.

Faculty from consortium of schools may learn and employ the techniques at their home institutions. LSU faculty will also have the opportunity to learn from visiting faculty and students—particularly, the knowledge required to effectively mentor and recruit minority students. Visiting faculty will also have an opportunity to interact with LSU researchers in their area. The program will help to develop a regional center of activity in Baton Rouge.

Graduate students and faculty will guide undergraduate students in the VIGRE REU. The experience will provide valuable educational and professional development to the graduate students. VIGRE REU students will also pick a mathematical education program in which to collaborate (see below). There will be a common time available each afternoon for interactions. This model draws on best practices from the University of Chicago Summer REU program, which incorporates 60 undergraduates into their *Young Scholars Program* and teacher education program *SESAME*. VIGRE advisory board member and University of Chicago VIGRE Co-PI, Paul Sally, will be an advisor on forming these interactions. Consortium faculty may be incorporated into the VIGRE REU and Faculty Lecture series.

Programs VIGRE REU students may choose for collaboration are:

High School Program I: The *LSU MathCircle summer enrichment program* is operating under NSF/GK-12 and State grants. It is a three-week summer enrichment program geared toward advanced high school students interested in investigating concepts in mathematics, engineering, and physics that are not usually introduced at the high school level. Exceptional students may be invited to participate in the VIGRE REU.

High School Program II: ACT Test Prep Academy. Student participants are largely minority students. They are recruited with the help of the Baton Rouge Chapter of *One Hundred Black Men*. Followup is also performed with the help of *One Hundred Black Men*. The main goal of this program is ACT preparation and content review. Forty high school students meet 9:30 am until noon. Test preparation is concentrated primarily on mathematics, but there is some exposure to English and reading portions of the exam. The participants are students who are all trying to raise their achievement for college. They are a good target audience for VIGRE since many are talented and motivated, but have lacked opportunities. With VIGRE, we would extend the session into the afternoon and add mathematical enrichment activities, MathCircle activities. The program is primarily operating under NSF/GK-12 and State grants.

Master of Natural Science teacher program: This is a summer program for in-service mathematics teachers and recent graduates that will begin at LSU. It is a program that takes just over two years and includes three summers. It leads to a Master of Natural Science (MNS degree). The program is to be mathematics content based and courses are taught by mathematics faculty.

The high school programs operate under the direction of VIGRE Steering Committee member Frank Neubrandner. The MNS degree program was developed and will be run by mathematics faculty Frank Neubrandner, James Madden, and Scott Baldrige.

Graduate students with GAANN, Board of Regents Fellows, NSF/GK-12, and VIGRE support will participate in the summer program. Graduate student participation in our present summer programs is presently limited to NSF/GK12 supported graduate students. Part of the GK-12 commission is that graduate students work with K-12 students and much of that work is to bring students up to speed to enter into Science, Technology, Engineering, and Mathematics. Basic tutoring is not necessarily compatible with the Board of Regents Fellowship program and GAANN since their goal is the professional development of the graduate students. Nevertheless, there is uniform agreement among the PIs of the above programs that working with undergraduate REU students and high school students engaged in advanced study and mathematical enrichment activity is valuable professional development. We also expect that feedback will develop in this structure. For example, the potential for Louisiana high school students to work on REU-type projects among college students with LSU graduate students and faculty will likely draw more talented high school students than the present program. High school students will also be recruited into the summer program on

Mathematics Circuit trips (see below).

The summer program will use existing programs to advance the VIGRE goals which will give the VIGRE investment a multiplier effect. The high school programs and the MNS program will run with or without VIGRE, however the nature of these programs can be influenced by VIGRE. The key to the transformation is the inclusion of the summer REU, and its implementation will allow wider graduate student inclusion. In addition to the high school, MNS, and National NSF-REU programs, there is also a Math Summer Camp for younger students (middle-school aged). NSF GK-12 fellows work with these young students and the camp is also supported by the organization *One Hundred Black Men*. The PIs may consider including the Math Camp in the future. The summer programs may vary with funding, however LSU has a strong record of outreach/enrichment programs and we will be flexible in our future plans to creatively incorporate them.

6.7 The Mathematics Circuit

One impediment to attaining more mathematics majors is that many Louisiana high school students do not even consider majoring in mathematics. This impediment can be seen in the ACT survey *Intended College Major Choice* indicating students intended college major. From the class of 2006, only 0.29% of Louisiana students selected mathematics compared to 0.39% nationwide. *There is a lack of mathematics enrichment in Louisiana at the high school level.* This lack is likely in part the cause of the low interest in entering mathematics among high school students. We will use our connection to high school faculty established through our many educational grant funded programs, the LSU Mathematics Contest for high school students, and our connections with Louisiana MA Θ (a national organization of high school mathematics clubs).

A faculty member and a graduate student will visit high schools in Alexandria, Lafayette, Lake Charles, Natchitoches, and Shreveport—traveling in one large circuit like an old circuit court. The faculty member will give a fun and interesting mathematical talk—perhaps akin to the Serge Lang high school talks—to get students involved in a follow up discussion. The graduate student may talk about more personal matters of their life in mathematics as an undergraduate and graduate student, their attraction to mathematics, and perhaps job prospects and interests. The opportunity will also be used to discuss with high school teachers and students in an informal gathering after the talks.

Sharon Besson, who is now in the LSU Cain Center and was the former president (up to 2006) of Louisiana MA Θ , will help Professor Jacek Cygan (our present LSU Mathematics Contest organizer) in making the necessary arrangements and contacts below.

While the mathematical enrichment and recruitment of mathematics majors from high school students is not explicitly mentioned as part of the VIGRE program, the transition from high school to college is recognized as a key transition point in ESW21 and is clearly relevant to the pipeline philosophy of VIGRE. *The primary purpose of the Mathematics Circuit will be to encourage students to enter mathematics wherever they may eventually attend college, but we may do some recruiting to LSU and for the high school summer programs.*

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