Department of Mathematics
Plan for Assessing and Improving
Student Learning in Degree Programs

May 8, 2008

1 Past Assessment Results

Both the undergraduate and the graduate programs in mathematics continually evolve as the result of on-going assessment. Much of the change follows from the normal governance of the programs, but in recent years some has been the result of special assessment exercises. Rather than attempting to trace anything back to the 1999 Assessment document filed by the department, we will briefly outline our regular oversight structures and describe the special assessment exercises we have undertaken. In the next section we will detail some of the most significant changes that have been implemented and our plans for assessing their outcomes.

The Mathematics undergraduate and graduate programs are headed by a Director of Undergraduate Studies (DUS) and a Director of Graduate Studies (DGS) respectively, both of whom are full professors in the department. They have primary responsibility for the academic aspects of the programs. The Associate Chair of the Department supervises all TA assignments. The department has two standing committees, the Undergraduate Affairs Committee (UAC) and the Graduate Affairs Committee (GAC), whose purpose is oversight and continual assessment of their respective programs. The UAC comprises eight faculty, one undergraduate and one graduate student; the GAC has eight members, including two graduate students. The program directors serve as ex-officio members of the committees.

The undergraduate program in mathematics has undergone significant changes in the last ten years. The intent of these changes has been to provide an enhanced mathematical experience for our undergraduates, whether they take a single introductory-level mathematics course or major in mathematics with the goal of doing further study at the graduate level. Important changes over the last decade have occurred in placement techniques for entering students, format of instruction in calculus and other large-enrollment courses, creation of new courses with more specific audiences than heretofore, and revisions in the requirements for majors, as well as many other areas. In some cases, assessment mechanisms are already in place; in others, assessment strategies are still to be devised and implemented.

In recent years the department has participated in, or initiated, the following special assessments of the graduate program.

- Alumni Visiting Committee: In 2003 the Department invited a group of 4 distinguished alumni of our Ph.D. program, headed by Richard Hain (Chair of the

Mathematics Department at Duke University) to assess our graduate program.

- Carnegie Initiative on the Doctorate (CID): Ours was one of 7 mathematics departments that participated in a five-year multi-discipline study (ending in 2005) of the American Doctorate by the Carnegie Foundation for the Advancement of Teaching.

- Ph.D. Completion Project: Our department participates in programs coordinated by the Graduate College as part of the Council for Graduate Schools Ph.D. Completion Project. The main focus of the program is on attrition in Ph.D. programs.

These assessment exercises resulted in several changes or innovations, most notably the creation of our Research Experiences for Graduate Students (REGS) program and the introduction of graduate mini-courses. Both are described more fully in Section 2.3. Our involvement in the Ph.D. completion project gave us early access to the Graduate College Program Profiles database, an exceptional utility which we now routinely exploit for assessment purposes.

In addition to Program Profiles, we employ a wide range of tools for tracking outcomes and assessing the overall state of our programs. These include a database (called GradInfo) in which extensive details of each graduate students' progress are recorded (comprehensive exams passed, dates of preliminary exams, progress review meetings with dissertation committees, etc.), annual progress review questionnaires, TA evaluation and ICES forms, and exit surveys. We maintain a separate GradArchive database in which we track career details of all alumni.

In Sections 2.2 and 2.3 we describe some of the most significant recent changes in the undergraduate and graduate programs and indicate the assessment measures that are either already functioning or are contemplated.

2 Revised Assessment Plan

2.1 Process

The Chair appointed an Assessment Committee consisting of the Associate Chair (Robert Muncaster) and the Directors of the Undergraduate and Graduate Programs (Joe Miles and Steven Bradlow). The committee solicited input from the UAC and GAC. Following advice gleaned from the Assurances of Learning workshop organized in Fall 2007 by the Center for Teaching Excellence, each committee was asked to discuss a mission statement, learning goals, measurable objectives, and where the desired skills and objectives are acquired in their respective programs. Against the backdrop of these discussions, the Assessment Committee prepared a draft report on recent significant changes and plans for assessment of the resulting outcomes. The draft was submitted for commentary and revision to the UAC and GAC, and discussed with the department Executive Committee. The final report incorporates the input from these discussions.

2.2 Student Outcomes: Undergraduate Program

2.2.1 Revision of the Math Major

After comparing our requirements for a math major to those at peer institutions, the UAC recommended that the undergraduate program be strengthened. It was recommended that abstract algebra (Math 417) be required of all majors, and that a proof-oriented linear algebra course be created as part of the new major. In addition, certain elective choices were modified in the various options. These recommendations have been approved by the College, and it is expected that they will be in place by the Fall of 2008.

As these changes have not yet been implemented, it is much too early to assess their impact. An important early indicator will be the number of students majoring in mathematics. As the bar is being set higher, a modest decrease in the number of majors is to be expected. A precipitous decline in numbers, on the other hand, would raise the question of whether the change in requirements was too extreme. Beginning with the graduation of the first class subject to the new requirements, data gathered by the Undergraduate Office on job placement will indicate whether the more challenging requirements have resulted in our graduates being more attractive to employers.

2.2.2 Revision of the Calculus Sequence

Three major changes in the calculus sequence have been implemented in the last four years, some still in the experimental stage and others mature enough that it is time for a careful assessment. These changes are (a) a significant content revision of third-semester calculus; (b) an alternative to second semester calculus designed for students in the College of Engineering; and (c) a second semester calculus course designed for students in Biology.

(a) After extensive discussions with Engineering, the integral theorems of vector calculus were moved from Math 380, Advanced Calculus, into Math 241, Calculus III. This important material for engineering curricula is now studied by engineering students at the latest in the third college semester of mathematics. Most peer institutions and even many community colleges had included this material in Calculus III for some time. Math 380 will be discontinued effective in the Fall of 2008. A four-hour version of Calculus I, Math 221, was introduced so that engineering students could still complete the calculus sequence in 11 hours.

The material moved from Math 380 into Math 241 is inherently more difficult than the other material in Math 241. Whether the students can learn this material effectively in the very tight syllabus of Math 241 will be the subject of ongoing discussions involving Math 241 instructors, the math department undergraduate office, and the College of Engineering. Alternative approaches to this expanded version of Calculus III are currently being field-tested in small sections. The results of these experiments will be a key part of the assessment discussion. Exit surveys for Math 241 students, distinct from ICES forms, and aimed entirely at course content rather than instructor evaluation, would also add a valuable perspective to assessment of this modification of Calculus III. Such exit surveys could begin in the Spring of 2008 and would be ongoing. Similar assessment considerations apply to the four-hour first semester calculus course Math 221, although there are no experimental sections currently being conducted.

(b) An alternative to Calculus II for engineering students with suitable AP credit, eventually to be offered as Math 236, was introduced first as a small scale experiment

in the fall of 2005 and now has been successfully run on a large scale. The rationale for such a course was that engineering faculty had been dissatisfied with the ability of their students to apply concepts learned in math courses to situations encountered in engineering. Working closely with engineering faculty, we have designed a course whose goal is to prepare students better than a traditional calculus course for the sorts of mathematical issues they will face in advanced engineering courses. A small-scale experimental section of Calculus I with the same goal will be taught in the Fall of 2008.

A small sample of students from a regular Math 231 (Calculus II) class and the Engineering Calculus course were given the same exam at the end of the fall semester of 2007. The results of that exam are being studied by members of the College of Engineering involved in the creation of the new course. Based on the results of that experiment, changes could be contemplated for either or both of the courses involved. The success in future math courses of students who took the newly-designed course will be monitored, beginning with data from the spring of 2008. Continued discussion with Engineering faculty regarding the mathematical preparation of their students will also contribute to assessing the success of the new courses.

(c) A version of Calculus II designed to be of greater value to Biology students than the traditional course was introduced on a small-scale experimental basis in the fall of 2007. Biology faculty are keenly aware that their field is moving in a direction that requires students to possess greater quantitative skills than the present curriculum produces. It is expected that the new Calculus II course will eventually be part of a mathematics requirement expanded by one course from the present level for all students in biology. The number of students involved is very large (some 800 per class), and significant questions of resources remain to be resolved before implementation on a large scale can occur.

Large-scale implementation is well in the future. While the course is still in the experimental stage, assessment will be based on tracking the success of students from the course in future math courses (such as Math 241) and on reports from faculty in biology concerning whether these students indeed have the quantitative skills needed in the biology curriculum.

2.2.3 Pre-calculus Revision

In the Spring of 2007 the department introduced Math 115, Precalculus, in response to some poor results the department had been experiencing in Math 116. Substantial numbers of students who emerged with grades of A or B from Math 116, a course in college algebra and trigonometry, were subsequently found to be failing Math 220, the course for which Math 116 was ostensibly preparing them. Math 115 has a much greater emphasis than does Math 116 on concepts such as limits that are of direct use in calculus. The gateway to calculus for students entering with minimal preparation is now Math 012 followed by Math 115. To date the results from Math 115 are encouraging, with large enrollments and better results as the students move on to Math 220. We expect to gather data to track the success in calculus of students who have taken Math 115.

2.2.4 Exit Survey and Alumni Database

The undergraduate office recognizes the need for more detailed knowledge of the views of our alumni on the undergraduate program, and seeks to maintain ties to the extent possible after graduation. Currently we have little if any information on the employment of our graduates, and better information in this regard would help in advertising our program and recruiting students to it.

Both exit surveys and an accurate database of our graduates have obvious implications for evaluating student satisfaction with particular aspects of our program and for gauging the success of our program in placing students in attractive positions. A more detailed exit survey will be given to graduates effective in May 2008, and greater care will be given to analyzing the responses, especially to open-ended questions concerning strengths and weaknesses of the program.

2.2.5 Honors Sequence

In 2002 the department introduced the first of what is now a four-course honors sequence targeted at extremely gifted mathematics students. This program accepts students in all majors and indeed many successful participants have come from various departments in Engineering. With the introduction of this sequence, our department now offers courses that challenge the very brightest of our undergraduates.

The intent of this program is to inspire our best math students to seek careers as research scientists, preferably as mathematicians. Since the number of students involved is quite small, tracking the careers of these students after graduation is a relatively easy task. A different type of assessment of the program could be based on audience size. If the enrollments in the honors courses do not rise above current levels, the Honors Committee in conjunction with the Director of Undergraduate Studies should discuss possible modifications in the courses to make them attractive and accessible to a wider group of students. Both of these approaches could begin in the Spring of 2008.

2.2.6 Strengthening Ties with Local Schools

In 2006 we began offering a course in tutoring aimed at those majors planning to apply to the secondary education minor. A significant component of the course is actual tutoring in local schools. This course gives students a realistic view of high school math instruction from a teacher's perspective, thereby helping them decide if this is a career in which they are truly interested. This course was introduced in part because it had been noted that some students went through the entire secondary education math minor before realizing that a career as a high school teacher was not appealing to them. In addition the program provides a presence for our majors in the local schools, emphasizing our department's commitment to mathematics education at all levels.

This program could be evaluated most naturally via exit surveys for math majors in the secondary education option, as well as through feedback from teachers in local schools. This assessment could begin in the spring of 2008.

2.2.7 Course Stewards

The UAC has recommended that a course steward be appointed in each of our undergraduate courses with a large enrollment. The role of the course steward would be to provide information to the instructors of these courses from the perspective of someone who has taught the course multiple times. Before the semester begins the steward would provide to the instructors a packet containing such information as historical grade distributions and ICES scores for the course, sample exams, and tips about what works well and what are possible pitfalls. In addition the steward would be available for consultation throughout the semester. The intent of this program is to provide insight into teaching a particular course from the perspective of an instructor experienced with that course, while allowing ample room for each instructor to put his or her individual stamp on the course.

After this program has been implemented for a year or two, it could be evaluated by surveying both the stewards and the instructors. Input from both groups as to what works well and what does not should result in an improved program. This assessment would be ongoing.

2.2.8 Placement of Entering Students

Introduced in the 2007 Fall semester, the online placement system ALEKS is now used for most students in courses below Calculus II. Effective in the fall of 2008, all entering freshmen are required to take the ALEKS placement exam. The objective is to place entering students more appropriately than before, resulting in fewer registration changes after the first hour exam and a more successful first semester mathematics experience.

Analysis of the success of this placement mechanism is ongoing; ALEKS benchmarks are already being reset in light of the fall 2007 experience. This program lends itself quite naturally to accurate assessment of success. At this point there is considerable optimism that ALEKS results in significantly more accurate placement than did the previous system of ACT scores. The accuracy of placement can be measured both by numbers of students transferring to other math courses during the semester, and by the success of the students in the courses in which they are placed. Data will be analyzed to compare the ALEKS placement score to other factors such as high school GPA, ACT score, and overall UIUC GPA as a predictor of success in calculus.

2.2.9 Online Homework Systems

Online homework systems have been an option available to instructors in many large enrollment courses since the fall of 2003.

In the fall of 2007, the department used the online system MATHZONE on a large scale for the first time. Four experiments were conducted in which an instructor used MATHZONE in one section, but not in another, and essentially identical exams were given to the two sections. Results of these experiments will be taken into account in curriculum development and course design decisions. At this early stage the effect of the online homework component seems to have been detrimental to exam performance in college algebra, and, on balance, neutral in calculus. The experiment is ongoing.

2.2.10 Expansion of the Merit Workshop Program

The Departments of Mathematics, Chemistry, and Integrative Biology recently submitted an NSF grant proposal aimed at increasing the number of students in science, technology, engineering, and mathematics. As a result of this proposal being funded, the math department expanded its Merit Workshop Program by four sections in the fall of 2007 and anticipates a further expansion by two sections in the fall of 2008. The department now offers Merit classes in Math 115, Math 220, Math 221, Math 231, and Math 241. The target groups for this program are underrepresented minorities, students from rural high schools, and students in the Division of General Studies.

The program is currently undergoing assessment by PS International, an evaluation group based in Annapolis, Maryland. PS International has evaluated surveys executed in the fall of 2007 by students, TAs, and Directors involved in the program. The intent of the surveys is to gauge the success of the program in its four major goals: academic performance, self-confidence, productiveness in working groups, and success in an alternate working environment. Further evaluation regarding recruitment, retention, and graduation rates will occur in subsequent reports from PS International. The Department of Mathematics is attempting to create a database that will facilitate tracking of participants in the Merit Program in subsequent math courses, as well as tracking those students who were invited to participate in the Merit Program but declined.

2.3 Student Outcomes: Graduate Program

2.3.1 Changes in the Comprehensive Exam Requirements

The GAC voted in Fall 2007 to change the comprehensive exam ("comp") requirements for Ph.D. students from 6 comps in 2.5 years to 5 comps in 2 years. The change is intended to reduce the time taken to complete the comps, hasten the transition to active research, and thus reduce overall time-to-degree. The full efficacy of the change (i.e. the expected time from completion of the comprehensive exam requirements to final defense) will take at least 3 or 4 years to be noticeable, but by Fall 2008 it should already be possible to discern an impact on the time taken to complete the exam requirements. Using data collected in GradInfo, the DGS and GAC will conduct such a study.

2.3.2 Mini-courses

The Department started offering graduate mini-courses in Spring 2005. These 7-week courses are intended to give an overview of a research area. The idea arose out of the Department's participation in the Carnegie Foundation Initiative on the Doctorate, where we learned of similar courses introduced by the Duke University Mathematics Department. In Spring 06 we conducted a simple poll of those who gave or took the mini-courses. It's time now for a more detailed examination. The best metrics available for assessing the success of the innovation are the number of courses offered, enrollment figures in each course, and instructor/student comments. After the completion of the current academic year we will tabulate and analyze the first two, using Banner data. We will poll the instructors and students in a special survey in Fall 2008 or Spring 2009.

2.3.3 Research Experiences for Graduate Students

In 2002-03 the GAC prepared a report on time-to-degree in the Ph.D. program. The report identified the transition from coursework to research as a common obstacle to timely progress. As a result of this study, and also as a result of the department's involvement as a partner in the CID, the GAC proposed a summer program called Research Experiences for Graduate Students (REGS). The program is aimed at Ph.D. students at the end of their first or second year and provides modest summer support for REGS Fellows to work on research projects under the supervision of a faculty member. While not necessarily related to eventual dissertation topics, the REGS projects should aim to produce publishable results. All participants are required to submit a final report.

Important measures of the program's effectiveness include the number of papers published, the time taken for REGS participants to pass the Preliminary Exam, and their overall time-to-degree. The first two indicate whether the experience was effective in involving participants in research; the third is a rough measure of whether the early exposure to research is effective in shortening time-to-degree. The time-to-prelim and time-to-degree data may be extracted from our GradInfo database. A preliminary analysis (in May 2007) strongly suggests that the REGS program is effective in reducing time-to-degree. It showed that 20 students who participated in the program in 2003 and 2004 had an average time-to-degree of 5.9 years, while the overall average for the Ph.D. program is 6.4 years. A more extensive study will be undertaken next year. Some information on papers published is already available in the final reports filed by all REGS participants, but will be supplemented by direct enquiries to all REGS participants.

2.3.4 Graduate Mathematics Open House

In 2007 the Department organized its first Graduate Mathematics Open House (GMOH), as a way to improve recruiting for its Ph.D. and Masters programs. The event is open to all prospective students, with travel subsidies available to applicants who have been admitted with financial aid. The GMOH includes informational sessions, panel discussions, personalized interview schedules with faculty members, tours of the Department, and social events. The 2008 GMOH took place on March 6 and was attended by 25 applicants from all over the country.

The success of the event is measured by (a) the number and nature of those who attend (i.e. what fraction of those admitted and of those offered aid, and where they lie in our own ranking of applicants), (b) the effect of the event on acceptance rates, and (c) responses to questions in the exit surveys given to all participants.

Results from this year's GMOH are encouraging: of the 14 participants who had received offers of admission with financial aid, 6 accepted. This acceptance rate is significantly higher than the Department's average rate, which this year was 1 in 4.

2.3.5 Dissertation Committees and Progress Reviews

In Fall 2005 the GAC mandated that students should meet with Dissertation Committees at least once a year for the committee "to hear a progress report from the student and to discuss plans for completion of the thesis". Initially, only students whose progress was seriously behind schedule or otherwise problematic were asked to

schedule such progress reviews, and the dissertation committees were appointed in an ad hoc way.

In Spring 2006 we started appointing dissertation committees for all students actively working on a thesis project. A committee is now appointed immediately after a student passes the prelim exam and is tasked with tracking the student's progress to completion of the thesis. Students are asked to meet with their dissertation committee at least once a year, with the format of the meeting left to the student and committee to decide.

It is time to assess how well the system is working, and whether it is having a measurable impact on student progress and thesis quality. Committee appointments and progress review meetings are tracked in GradInfo. Questions about both are included in the Progress Review survey filed each Spring by post-prelim students as part of their requests for re-appointment. In addition, faculty will be surveyed to gauge their view of the system and its impact.

3 Plans for Using Results

3.1 Plans

The assessment procedures described above will, for the most part, be carried out or supervised by the UAC and GAC, in conjunction with the directors of the undergraduate and graduate programs. It will be their responsibility to analyze the results and recommend appropriate action.

3.2 Timeline

See table.

Change or Innovation	Date Implemented	Assessment Date	Assessment Tools/Method
Revison of Math Major	Fall 2008	Fall 2010	Class sizes; job placement
Calculus Revisions	(a) Engineering Calculus Fall 2005 (b) Calculus III Fall 2006 (c) Biocalculus Fall 2007	(a) Spring 2008 (b) Spring 2008 and ongoing	(a) common exams with Math 231; track success in future math courses; feedback from Engineering faculty (b) faculty survey; student questionnaires and continuing discussions with Biology faculty
Pre-calculus Revision	Spring 2007	Fall 2008	Track success of Math 115 students in calculus
Undergrad Exit Survey	Spring 2008	Summer 2008 and ongoing	Analyze results and modify survey as necessary
Honors Sequence	Fall 2002	Spring 2008	Track career path of alumni via coordination with Honors Committee; ongoing discussions with Engineering regarding recruitment
School Ties	Fall 2007	Spring 2008	Surveys of tutors and school teachers
Course Stewards	Fall 2008	Fall 2009	Surveys of stewards and instructors
ALEKS	Fall 2007	Fall 2008	Banner data mining
Online Homework	Fall 2003	Fall 2008	Controlled experiments
Expansion of the Merit Workshop Program	Fall 2007	Fall 2007 and ongoing	Surveys of students, TAs, and Directors by PC International; tracking of participants in subsequent math courses by the department
Comp. Exam Requirements	Fall 2007	Spring 2009	Time-to-completion data; Time-to-degree
Graduate Mini-Courses	Spring 2006	2008-09	Enrollment figures; survey
REGS	Summer 2003	Fall 2008	Time-to-degree and other progress milestones recorded in GradInfo; papers published;reports
GMOH	Spring 2007	Fall 2008	Exit survey; recruitment data
Dissertation Committees / Progress Reviews	Spring 2006	2008-09	Time-to-degree, time from prelim to completion; survey of faculty

Table 1