



August 21, 1995

To: Phillip R. Certain, Dean

From: Richard A. Brualdi, Chair

Re: Department of Mathematics Plan for Assessment

Enclosed is the Department of Mathematics Plan for Assessment for the Undergraduate Major and the Graduate Program. The Department of Mathematics was happy to cooperate with the College by developing a pilot assessment plan. We would be pleased to meet with you or Associate Dean Alexander Nagel to discuss this plan should you have any questions about it or require some clarification.

xc: Interim Dean of the Graduate School, Charles Read
Associate Dean of L&S, Alexander Nagel
Associate Dean of the Graduate School, Terrence Millar
Chair of the 1995-96 Assessment Committee (Department of Mathematics),
Simon Hellerstein

DEPARTMENT OF MATHEMATICS

College of Letters and Science
University of Wisconsin - Madison

PLAN FOR ASSESSMENT of the UNDERGRADUATE MAJOR and GRADUATE EDUCATION

September, 1995

Introduction

The Department of Mathematics volunteered to develop a pilot assessment plan by the fall of 1995, after it was informed by the College of Letters and Sciences that all Departments and Programs would be required to do so by December 31, 1996. We would like to note that assessment activities are a part of the Departments ongoing activities. Student performance on examinations, initiation of new courses, revision of syllabi of established courses, student evaluation of courses, discussion of our course offerings with other Departments, one on one sessions with our students when advising them (inside and outside of the classroom), monitoring of our programs by our Undergraduate and Graduate Program Committees, the Departments newsletter *Reflections on Curriculum Innovation & Experimentation* are all assessment-related activities that have served the Department well and have improved the undergraduate major and graduate education in mathematics.

Formal assessment procedures, of the type we are asked to develop, are relatively new, certainly to Mathematics Departments in general and, as we understand, to most other Departments as well. Thus while we are eager to develop such procedures and hope that they will lead to changes so that future students will learn more mathematics and will understand and be able to apply it better, we also realize that we are embarking on an experimental venture and that the procedures we develop may undergo changes as we gain experience. We are also conscious of the fact that we want to keep our assessment activities in balance with our other activities. Our faculty are increasingly called on to assume additional responsibilities, and the benefits obtained in new activities should be commensurate with the time and effort they require.

We view a formal assessment plan as having the following major components:

1. *Articulation of the overall goals of our programs (What are the purposes of our programs?).*
2. *Statement of objectives matched to these goals (What should our students be learning?).*
3. *Development of instruments that measure the extent to which we are achieving our objectives (How well are our students learning what we teach?).*
4. *Implementation of these instruments to gather assessment data, followed by analysis and interpretation of this data (How should our programs be changed to better achieve our goals and objectives?).*

Each of these components is addressed in the sections below for the undergraduate major and for the graduate program. The ultimate purpose of our assessment plan is to improve our programs so that students will learn and retain more, will understand what they learn better, and will be able to apply what they learn in new and different situations.

The assessment plans articulated below for the undergraduate major in Mathematics and for the graduate program in Mathematics were developed, respectively, by the Undergraduate Program Committee and the Graduate Program Committee of the Department of Mathematics. Drafts of the plans were distributed to all faculty in order to obtain their input, and this resulted in a modified document. The plans were discussed at a Department meeting on May 11, 1995 and were approved by votes of 26-2-6 (undergraduate major) and 27-1-6 (graduate program). The chair (Richard A. Brualdi) has appointed an Assessment Committee for 1995-96 whose charge is to carry out the assessment plan for the undergraduate major. The Graduate Program Committee has been assigned the responsibility to carry out the assessment plan for the graduate program. The members of these committees are listed below.

Undergraduate Program Committee (1994-95): S. Angenent, S. Bauman, P. Miles, M. Osborn (chair), C. Rider, D. Uhlenbrock, M. Voichick).

Graduate Program Committee (1994-95): A. Assadi, W. Dickey (chair), D. Griffieath, S. Hellerstein, Y. Oh, D. Passman).

Assessment Committee (1995-96): S. Bauman, S. Hellerstein (chair), P. Miles, P. Orlik, M. Osborn.

Graduate Program Committee (1995-96): W. Dickey (chair), D. Griffieath, Y. Oh, L. Solomon, A. Tzavaras.

UNDERGRADUATE MAJOR

1. *Goals*

The overall goal of our undergraduate mathematics major is to produce students who understand and appreciate mathematics, who can use mathematics in understanding the world in which they live, and who can use mathematics as a basis for life-long learning. Included in this overall goal is the belief that completing the major in mathematics entails gaining sufficient subject competency to enable a student to achieve at least one of the following:

- a. To handle the mathematical demands of a technical entry level position in business, industry, or government.
- b. To pursue a graduate program in the mathematical sciences.
- c. To handle the mathematical demands in pursuing a scientific graduate or professional program.
- d. To teach mathematics in a secondary school.

To achieve these goals, the Department of Mathematics offers introductory and advanced courses ranging from calculus to linear and abstract algebra, topology, logic, probability theory, and complex and real analysis. Students have the option of designing a program to suit their interests subject to certain breadth and depth requirements, or designing a program that emphasizes some area of application, again subject to a depth requirement. The Department also has an honors program which has more rigorous depth requirements and which is excellent preparation for graduate study in the mathematical sciences. In conjunction with the Secondary Education Program of the School of Education, it offers a mathematics major for teaching mathematics in middle, junior high, and high schools. The Applied Mathematics, Engineering & Physics Program is a four year program in the physical sciences that provides a strong foundation in mathematics and physics with a substantial introduction to engineering science. All our majors are encouraged to take courses in computer science. More details on our courses, other offerings and activities are contained in the *Guidebook for Undergraduate Math Majors* which is attached as an appendix.

2. Objectives

Because of the variability in our goals, the objectives of our undergraduate major to match these goals are formulated in a way that emphasizes their commonality. Our objectives can be classified into those of knowledge, skills, critical thinking, and application. While our emphasis is on Mathematics courses, some of our objectives, e.g. communication skills (both oral and written) and critical thinking, are attained and reinforced through many courses given throughout the University.

Students completing the Undergraduate Major in Mathematics should have attained the following:

- a. Ability to use the language of mathematics both in its idiomatic and rigorous forms, to give a clear written or oral explanation of the meaning of certain fundamental concepts and statements and of how such concepts and statements apply in particular situations. This ability includes interpreting and using conventional mathematical notation.
- b. Facility with the basic mathematical techniques used in a required area of study, and a knowledge of the basic theorems in this area.
- c. Ability to formulate and test conjectures and to construct simple mathematical proofs.
- d. Ability to apply what one has learned in one mathematical area to another area, whether modeling a physical situation or interpreting one mathematical object or structure in terms of another.

3. Instruments for assessment.

Each instrument used for assessment should reflect the type of learning it is intended to measure. The suitability of a certain instrument will depend on what is being measured (knowledge, skills, aptitude, attitude, ...) and may depend on the relevant discipline. The Department of Mathematics is aware of several assessment instruments. These include *tests* (locally or nationally constructed), including *embedded questions* on exams; *exit interviews* and *surveys*; *portfolios* containing student work such as examinations, term papers, homework samples, journals, etc.; *capstone* or *summary courses*; and *seminars*. It is important to understand that the purpose of these assessment instruments is **not** to evaluate individual students or faculty but to evaluate our programs and to provide information about any discovered needs for change. It is also important to reiterate (see the Introduction of this document) that *ongoing-assessment* activities are a regular part of the Departments review of its program, and that these will continue even in the presence of the more formal assessment program being proposed here. Finally, it is important to note that our assessment program should encourage and not discourage

curriculum and pedagogical innovation.

After careful consideration, the Department of Mathematics has decided to focus on the following assessment instruments in this pilot phase of our assessment program. We plan to review the usefulness of these instruments periodically. Some of these instruments may be either abandoned or used less frequently, if the information gained is not of much value. Additionally, we may decide to try new assessment techniques. Whatever assessment instruments that we use, we require the cooperation of students, and the results obtained must justify the time and energy expended by all concerned.

(i) *Embedded questions*: The Assessment Committee working with the instructors teaching the selected course will identify a question, the *embedded question*, that will be made part of one of the usual course examinations. Performance on this question will be used by the Committee as a measure of attainment of the Departments objectives. The questions chosen will be of types normal for the courses chosen. The responses to the questions will be graded as usual by each instructor as part of their grading process. They will also be graded independently by someone hired to assist the Assessment Committee. The questions will normally be identified early in the semester by the Committee and the instructors involved.

The courses selected by the Committee will normally be chosen from the key courses Math 441 (Introduction to Modern Algebra) , Math 521 (Advanced Calculus), and Math 541 (Modern Algebra) of our undergraduate major, or other such courses as the Committee judges will yield useful data to measure progress toward the Departments objectives.

(ii) *Exit interviews and surveys*: On a periodic basis, the Assessment Committee will conduct exit interviews or surveys with graduating mathematics majors.

(iii) *Alumni surveys*: Every five to seven years, the Assessment Committee will conduct a survey of graduates of our undergraduate major, several years after they have graduated.

4. *Implementation of instruments of assessment*

Each year the Chair of the Department of Mathematics will appoint an Assessment Committee, which will be charged with carrying out the Departments assessment program. One or more courses central to our major program will be selected for assessment. The Assessment Committee and instructors will formulate an embedded question for some chosen exam. After the results have been graded, the Committee will meet with participating faculty and course coordinators for the courses involved (which may include prerequisite courses) to discuss the results and their implications for our undergraduate program.

The Assessment Committee will prepare an annual report for the Department and the College on its activities and its evaluation of the outcomes of the years assessment activities. This report will contain the Committees recommendations for changes in curriculum or pedagogy if the assessment measures indicate that some action is called for. It may also include recommendations for changes in the instruments of assessment used if the Committee believes that those currently being used are not effective or are inadequate for obtaining the desired information. It shall meet with the Undergraduate Program Committee to discuss possible program modifications or improvements relative to the findings in its report. The Assessment Committee will implement the instruments of assessment beginning with the second semester of the 1995-96 academic year, with a first report available within the first few weeks of the 1996-97 academic year.

GRADUATE PROGRAM

1. Goals

The overall goal of the graduate program in mathematics is to provide knowledge and training in advanced mathematics. While the Department of Mathematics encourages students to take advanced courses in mathematics for the intrinsic beauty of mathematics and its usefulness in understanding the natural and physical world, most graduate students have a specific degree goal in mind:

- a. A Ph.D. degree in mathematics,
- b. An M.S. degree in mathematics,
- c. A minor in mathematics as part of a Ph.D. program in another discipline.

a. The goal of the Ph.D. program is to provide the student with a broad knowledge of mathematics and the guidance to produce, and present in a clear and understandable way, an original and substantial piece of mathematical research. The program is intended to serve both students who wish to be professional mathematicians and scientists, whether in the university, industry or business, and those students whose mathematical training is simply a major component of a liberal education.

b. The goal of the Masters program (including the joint Masters program in mathematics and education) is to provide students with advanced mathematical training for appropriate career goals such as teaching and jobs in industry and business for which mathematical skills and training are useful and important.

c. The goal of the minor program is to provide a student whose primary interest is in an area other than mathematics with appropriate mathematical knowledge and training.

To achieve these goals, the Department of Mathematics offers advanced courses in algebra (including groups, rings, fields, representation theory, combinatorics and graph theory, number theory), analysis (including real and complex analysis, ordinary and partial differential equations, probability), applied mathematics (including fluids, elasticity, solids, scientific computation), logic (including foundations, model theory, recursion theory, set theory), and topology (including algebraic and differential topology, geometry),. In addition, the Department offers a substantial number of seminars each semester on topics of current research interest and, organizes a weekly colloquium series with presentations given by distinguished mathematicians from many domestic and foreign universities. Students in the Masters program are required to take an advanced course in computer science; Students in the Ph.D. program are encouraged to take a minor in disciplines, such as computer science, statistics, and engineering science, in

which mathematics is applied. Courses, seminars, colloquia, and supervised independent study afford the student in the Ph.D. program the opportunity to acquire a broad background, and to reach the frontiers of research in her or his chosen area of specialization, and then to conduct research under the supervision of a faculty member. More details are contained in *Graduate Programs in Mathematics* which is attached as an appendix.

2. Objectives

The objectives of the graduate program in mathematics to match the goals formulated above are:

a. Students completing the Ph.D. in Mathematics should have substantial general knowledge of advanced mathematics and a specialist knowledge of some specific area of mathematics. They should have demonstrated the ability to apply mathematical techniques to new problems and to contribute new mathematical knowledge of a substantial interest. In addition, they should have developed good communication skills for both oral and written presentations of mathematics.

b. Students completing the Masters Program in Mathematics should have a substantial general knowledge of basic mathematics and a knowledge of how one area of mathematics is used in another or in an area of application. Students completing the Joint Masters Program in Mathematics and Education should have a substantial general knowledge of mathematics and a basic knowledge of educational practice.

c. Students completing the Minor Program in Mathematics should have a substantial knowledge of mathematics in their area of interest.

3. Instruments for assessment

The assessment instruments described below will be used in this pilot phase of assessment of the graduate program in mathematics. Many of these assessment instruments are currently being used.

a. (i) Collect data on success and failure on the qualifying exams for the Ph.D. in each of the areas it is given. (The qualifying exams test general knowledge of advanced mathematics, and currently are given in algebra, analysis, applied mathematics, logic and topology. Students must pass two of the qualifying exams.)

(ii) Collect data on success and failure on the speciality exams for the Ph.D. (The speciality exam tests specialist knowledge in a specific area of mathematics, related to a student's proposed research.)

(iii) Collect data on the number of students who withdraw from the Ph.D. program without completion of the program, and conduct exit interviews with such students on a regular basis.

(iv) Collect data on the employment successes and failures of our Ph.D. graduates. For academic employment, this data should indicate whether mathematical research is a substantial component of ones duties, or whether ones duties are primarily or wholly teaching duties at the undergraduate level. For industrial employment, this data should contain information on the type of work one is expected to be engaged in.

b. (i) Collect data on success and failure rates on the Masters exam.

(ii) Collect data on the number of students who withdraw from the Masters program without completion of the program, and conduct exit interviews with such students on a regular basis.

(iii) Collect data on the employment successes and failures of the graduates of our Masters program including information about the kind of work expected to be engaged in.

c. (i) Conduct exit interviews with students in the Math Minor Program on a regular basis.

4. Implementation of instruments of assessment

The Graduate Program Committee will be responsible for carrying out the Departments assessment program in graduate education. The Committee will prepare an annual report on its assessment activities and its evaluation of the outcome. On the basis of that report and discussion within the Department, it may recommend program modification or other action by the Department. The Committee will implement the instruments of assessment beginning with the second semester of the 1995-96 academic year, with a first report available within the first few weeks of the 1996-97 academic year.