The Mathematical Association of America

Guidelines

for Programs and Departments in Undergraduate Mathematical Sciences

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GUIDELINES FOR PROGRAMS AND DEPARTMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCES

A. Introduction

In 1989, the National Research Council published the report, "Everybody Counts: A Report to the Nation on the Future of Mathematics Education," [37]. That report characterized undergraduate mathematics as the "linchpin for revitalization of mathematics education" and reminded us that "critical curricular review and revitalization take time, energy, and commitment."

Since 1989, several other reports of national organizations included recommendations for strengthening this linchpin role of undergraduate mathematics. These documents include "Moving Beyond Myths: Revitalizing Undergraduate Mathematics," [38]; "Challenges for College Mathematics: An Agenda for the Next Decade," [6]; "The Undergraduate Major in the Mathematical Sciences," [17]; "A Call for Change: Recommendations for the Mathematical Preparation of Teachers of Mathematics," [28]; "Principles and Standards for School Mathematics," [35]; "Heeding the Call for Change: Suggestions for Curricular Action," [52]; and "Recognition and Rewards in the Mathematical Sciences," [26]. The Guidelines that follow incorporate many of these recommendations.

This document supports the many curricular reports by presenting a set of recommendations that deal with a broad range of structural issues that face mathematical sciences departments and their institutional administrations. The document includes statements on planning and periodic review, faculty and staffing, curriculum and teaching, institutional and departmental resources, physical facilities, libraries, and services to students such as advising and co-curricular activities for majors. As such, these Guidelines deal with all aspects of the undergraduate mission—general education, mathematical sciences courses serving other disciplines, and the mathematical sciences education of majors, including future secondary teachers. They are intended to address mathematical sciences programs in four-year colleges and universities but many of the guidelines also apply to two-year colleges. In June 1993, the American Mathematical Association of Two-Year Colleges (AMATYC) published the document, "Guidelines for Mathematics Departments at Two-Year Colleges," [57], which is a complement to this document. The AMATYC guidelines extend these Guidelines to two-year colleges, and they address more specifically the concerns of these institutions. The AMATYC Guidelines may be found at the AMATYC web address http://www.amatyc.org/publications.html/.

These Guidelines are intended to be used by mathematical sciences programs in self-studies, planning, and assessment of their undergraduate programs, as well as by college and university administrators and external reviewers. Mathematical sciences programs and their administrations can use the recommendations included in these Guidelines as a basis for allocating resources and planning for the future. It is the joint responsibility of institutional administrations and mathematical sciences programs to provide and use properly the resources necessary to meet these Guidelines.

In many institutions, faculty from more than one mathematical sciences discipline are in a department or program that also includes pure and applied mathematics. These Guidelines apply to all programs in such a mathematical sciences department. Such programs might include pure mathematics, applied mathematics, mathematics education, computer science, statistics, and operations research. In some institutions, academic programs may not be organized into traditional department units. These Guidelines are intended to apply to the mathematical sciences courses, programs, and faculty within those institutions as well. Application of these Guidelines to programs in separate departments of computer science, operations research, statistics, or mathematics education is not intended.

Throughout the document, the phrase "mathematical sciences" refers to a collection of mathematics-related disciplines, including, but not necessarily limited to, pure and applied mathematics, mathematics education, computer science and computational mathematics, operations research, and statistics. In this document, we use the word "department(s)" to include non-departmental mathematical sciences programs.

We urge that this Guidelines document be used as the starting point for the planning and evaluation process. Professional societies in the mathematical sciences can provide advice for the review process and on the selection of external reviewers. An excellent reference for a planning and evaluation process is the text, "Towards Excellence: Leading a Mathematics Department in the 21st Century," [22]. Though written for mathematics departments with doctoral programs, most of its chapters provide valuable information, conclusions, and advice for the review and evaluation process in all collegiate mathematical sciences departments. Chapter 20, in particular, "How to Conduct External Reviews," applies directly to the process. The text focuses on precisely the kinds of academic concerns and issues confronting mathematical sciences departments, their department and college leadership, and the faculty who deliver the programs.

Another source of information is the publication of the Association of American Colleges, "Program Review and Educational Quality in the Major," [7]. Important comparative data can be found in the MAA publication, "Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States, Fall 1995 CBMS Survey," [31]. Comparative data also can be found in the report of the AMS-ASA-IMS-MAA Data Committee's Annual Survey of the

Mathematical Sciences, published in three parts each year in the "Notices of the American Mathematical Society." The Fall 2000 CBMS Survey Report is published on the AMS website, e-MATH, and the MAA website, MAA Online. The Data Committee's Annual Survey reports also are published on e-MATH. For departments with graduate programs, the annual AMS publication, "Assistantships and Graduate Fellowships in the Mathematical Sciences," [4] gives valuable comparative information, not published elsewhere, about departments. This publication also is available at the e-MATH website.

Other resource documents that relate directly to the departmental planning and evaluation process include, "Reinventing Undergraduate Education: A Blueprint for America's Research Universities," [12], "The SIAM Report on Mathematics in Industry," [34], "Factors Contributing to High Attrition Rates Among Science, Mathematics and Engineering Majors," [46], "Twenty Questions that Deans Should Ask Their Mathematics Departments," [49], and "Models That Work: Case Studies in Effective Undergraduate Programs," [61]. As cited in the References Section, the first two of these reports are available on the internet.

B. Planning and Periodic Review

1. In cooperation with the dean or other appropriate administrative official, each mathematical sciences department should participate at regular intervals in a process of periodic planning and evaluation. Participants in the process should include faculty, students, alumni, client departments, external mathematical sciences reviewers, and deans or other administrators. The faculty and any external consultants directly involved in this review should adequately reflect both the program mission and the faculty of the mathematical sciences program or department being reviewed. The process should lead to a strategic plan, acceptable to the department and to its dean, for enhancing strengths and remedying deficiencies identified in the planning and evaluation process.

2. The major components of the planning and evaluation process should be:

    a. A statement that clearly defines the mission of the undergraduate mathematical sciences department.

    b. A delineation of the educational goals of the program as well as a statement of how attainment of these goals is expected to fulfill the mission of the program.

    c. Procedures for measuring the extent to which the educational goals are being met. These measures will, of necessity, be multi-dimensional since no single statistic can adequately represent departmental performance with respect to most departmental goals. Measures of student learning and other student outcomes should be included in the procedures.

    d. A process for regularly reviewing (and revising, if necessary) departmental and academic program components in light of measurements of program success.

    e. A departmental and institutional plan to allocate, over time, the resources needed to implement the strategic plan agreed to by the department and its dean.

3. The periodic reviews should examine all aspects of the department's undergraduate academic program. Reviewers should consider the departmental mission and goals statements, faculty and staffing issues, the extent to which the department's curriculum is consistent with those statements and with the needs of the students being served, evidence that indicates the extent to which the department's service courses give students the mathematical sciences background they need to take subsequent courses in other departments, evidence that indicates the extent to which the department's major program is successful in enabling students to meet the department's educational goals, the effectiveness of the department's advising practices, and the success of the department in recruiting and retaining students, including students from groups that are underrepresented in the current personnel pool of mathematical scientists. Curricular quality and effectiveness should be judged in comparison with mathematical sciences programs at peer departments, and in comparison with the most recent CUPM recommendations on the mathematics curriculum. When related to the department's goals, further indicators of program quality may include student performance in seminars, departmental comprehensive examinations, course-embedded assessment, undergraduate research activities, internships, consulting experiences, and national competitions and examinations (such as the COMAP modeling competition, the Putnam competition, the Data Analysis competition, actuarial examinations, and the GRE mathematics examination). Other indicators include student evaluations that are obtained through surveys and interviews. Reviewers should also consider the accomplishments of the graduates of the department's programs and, where appropriate, the number of mathematical sciences majors produced compared to peer departments and to national averages, the success of the associate degree recipients who transfer to four-year colleges, the success of bachelor's degree recipients who matriculate in post-graduate degree programs, and the employability of the department's associate or bachelor's graduates. Reviewers should also address institutional and departmental resources, including physical facilities and library resources.

C. Program Faculty and Staffing

1. EDUCATIONAL BACKGROUND

   a. Except as indicated in item c below, those who are hired to teach mathematical sciences courses for undergraduate credit should have a minimum of a master's degree in a mathematical science. This applies to both full-time and part-time faculty wherever the institution's courses are taught. In institutions that grant at least a bachelor's degree in the mathematical sciences, tenure-track faculty should possess a doctoral degree in a mathematical science.

   b. Mathematical sciences departments frequently offer courses in several disciplines, including pure mathematics, mathematics education, applied mathematics, computer science, operations research, and statistics. Ideally, a course should be taught by a faculty member with a graduate degree in the discipline of the course. In the many departments where this is not possible, the course should have a developer/coordinator, who has a graduate degree in that discipline. The developer/coordinator should hold regular meetings with the faculty teaching the course in order to discuss such items as the course syllabus, textbooks, resources, teaching methods, technical matters, and evaluation. The department's curricular needs should be a major factor in departmental hiring decisions. The number of faculty with expertise in a mathematical sciences discipline should reflect the department's courses and enrollments in that discipline. See also Guideline C.2.e.v and Guideline D.1.g.

   c. Since they are the future faculty members of our colleges and universities, it is important that graduate students have some instruction in teaching including serving as apprentice teachers. Thus, even though they might not meet the requirements above, mathematical sciences graduate students may teach or assist with the teaching of courses under the close supervision of faculty members. A graduate student who has a master's degree or equivalent in a mathematical science may be assigned as the independent instructor of record in a course. As is the case with all faculty teaching in the department, unless the graduate student's master's degree or equivalent is in the same discipline as the course, the course coordinator should consult regularly with the graduate student. In addition, the graduate student should be provided with the same resources for teaching that are available to full-time faculty teaching the same course, including office space, computer and library resources, and mentoring by full-time faculty. Other activities that are suitable for graduate teaching assistants include grading papers, staffing laboratories, conducting discussion or recitation sections, and tutoring.

   d. If undergraduate students assist in undergraduate instruction, their efforts should be restricted to classroom organizational duties such as collecting papers; reading and commenting on homework assignments; tutoring or assisting in mathematics and computer laboratories, mathematics workshops, and recitation sections; and holding supplementary instruction sessions.

2. PROMOTING EXCELLENCE IN TEACHING

   a. Teaching ability and commitment to teaching should be key factors in all appointments to the teaching staff.

   b. Orientation and training programs should be provided to familiarize new staff members with departmental expectations and the needs of students. New faculty should receive a description of the teaching and teaching-related duties expected of them and the means by which those duties will be evaluated.

   c. Faculty should be supervised, monitored, and evaluated in order to help them improve their teaching. See also Guideline C.8.f.

   d. The courses assigned to faculty, especially those newly hired, should be chosen to aid in their development as teachers.

   e. A regular program for maintaining and improving teaching expertise is essential for all academic mathematical scientists.

      i. Departments should provide long-term structured opportunities for acquisition and improvement of teaching skills by all who teach. This might be accomplished through demonstrations of pedagogical approaches and strategies for good teaching and may include videotaping and peer critiques, observing classes taught by outstanding teachers, team teaching with these teachers, or working with faculty mentors.

      ii. Departments should provide regular opportunities for and support the professional development of faculty members to learn of the most recent findings about teaching and learning in the mathematical sciences and of the most recent developments in technology that support teaching and learning. See also Guideline D.6.

iii. When a department decides to use technology in a course or program, it should offer appropriate training for faculty in that technology and its effective use in instruction.

iv. All full-time faculty members should participate regularly in activities to maintain and improve their teaching expertise. A suggested outline for improvement can be found in the CTUM report, "A Source Book for College Mathematics Teaching," [44] and in the first nine pages of "A Call for Change: Recommendations for the Mathematical Preparation of Teachers of Mathematics,"[28].

v. Participation in programs designed to assist college teachers is particularly important for members of a department who sometimes teach outside of their own mathematical sciences discipline. These programs should be extensive in scope and require substantial investment of time by participants. Many faculty have found that earning a master's degree or equivalent in a second mathematical sciences discipline or other discipline appropriate to the teaching assignment gives them the needed background.

vi. When instituting programs for the improvement of teaching by graduate teaching assistants and part-time instructors, consideration should be given to the characteristics of the model programs and the remarks presented in the introduction of the MAA publication, "Keys to Improved Instruction by Teaching Assistants and Part-time Instructors," [14].

f. In certain circumstances, part-time faculty can make unique contributions to a mathematical sciences department. Departments that employ part-time instructors should provide them with all of the resources necessary for teaching that are provided to full-time instructors, including office space as well as computer, Internet, and library resources. Full-time faculty should mentor part-time faculty in resolving problems, in meeting responsibilities, and in familiarizing them with the procedures and expectations of the department. See also the last two sentences of Guideline C.6.

g. Departments should ensure that senior faculty assume a leadership role in the undergraduate program by participating fully in teaching, curriculum development, and student advising. In addition, they have key responsibility for reviewing and nurturing junior faculty and teaching assistants.

h. Both senior and junior faculty should, at least on occasion, teach courses at all levels of the undergraduate program.

3. PROMOTING EXCELLENCE IN SCHOLARSHIP

a. All full-time faculty members should, as part of their work assignments, engage in disciplinary or interdisciplinary scholarship, broadly defined to include the discovery of new knowledge, the integration of knowledge, the application of knowledge, and scholarship related to teaching, "Scholarship Reconsidered: Priorities of the Professoriate," [11]. Successful scholarship includes the obligation of timely communication of results to peers. Faculty should sustain their scholarship throughout their careers. Guidelines for the acceptable forms of this scholarship and for the nature of communication of results to peers should be made available in writing to faculty members. A department should encourage, recognize, and value the diverse nature of faculty scholarship that is directly related to the department's mission and program goals.

b. A regular program for maintaining and improving disciplinary or interdisciplinary expertise is essential for all academic mathematical scientists. Departments should support professional development of faculty members to enable them to remain current with the most recent advances in the field. Appropriate development opportunities include participation in seminars, graduate level mathematical sciences courses, appropriate courses in other disciplines, conferences, symposia, short courses, and professional meetings. As all full-time faculty members should participate in appropriate professional development, such activities should be a part of each faculty member's work assignment. Sabbaticals, other faculty leave programs, faculty exchanges, and periodic workload reductions provide faculty the necessary time for professional development.

c. Mentoring programs and faculty development opportunities designed specifically for new faculty should be available, and all new faculty should be encouraged to participate in such activities. See Guideline C.8.f.

d. In order to foster a sustained commitment to scholarship among faculty, departments and their institutions should provide sabbatical or research leaves at appropriate intervals and should have generous policies allowing leaves without pay for research and scholarly activities.

4. PROMOTING EXCELLENCE IN SERVICE

a. Departments should expect senior faculty to seek and accept committee assignments within the department, the institution, and the profession. Departments should expect junior faculty to become involved in service, at a level consistent with local expectations for tenure, with the understanding that faculty governance responsibilities increase upon the award of tenure. See also Guidelines C.7.b. iii and iv.

b. Departments should expect all full-time faculty members to be formally involved in their professions by participating in professional organizations.

5. ASSIGNMENT OF DUTIES

In this section, "hours" will mean semester hours, and a "course" will be considered to carry three semester credit hours. Appropriate adjustments should be made for quarter hours, for labs, or for courses carrying credit hours other than three.

a. Institutional and departmental missions vary considerably. Work assignments for faculty should reflect institutional and departmental missions. They should be consistent with locally defined expectations for promotion and tenure as well as with comparisons to assignments in peer departments at other institutions.

i. Faculty for whom personnel decisions are based primarily upon assessment of substantial scholarly accomplishments or doctoral level teaching and research supervision should have teaching assignments that do not exceed two courses per semester.

ii. Faculty for whom personnel decisions are based upon assessment of contributions in teaching, scholarship, and service should have teaching assignments that reflect these multiple expectations and allow for attention to non-classroom responsibilities. Teaching assignments above three courses per semester, when combined with other faculty responsibilities, do not allow the time needed to develop and maintain a program of sustained scholarship with the result that tenure and promotion might be effectively unattainable. For such faculty, teaching assignments above the level of three courses per semester must be avoided.

iii. Faculty for whom personnel decisions are based predominantly upon assessment of teaching and service responsibilities must have sufficient time for class preparation, course development, conducting office hours, advising, and other duties in service of the profession in addition to formal classroom teaching. Teaching assignments that exceed five courses or a maximum of three different class preparations or fifteen contact hours do not allow sufficient time for these responsibilities.

b. Depending on department or program mission and priorities, appropriate reductions from the normal teaching assignments described above should be made for extensive involvement in professional activities or service. This may include such activities or service as committee or administrative assignments; course, courseware, program, or computational technology development; laboratory supervision; thesis direction; and scholarship.

c. In the assignment of duties, departments must exercise careful monitoring of an individual faculty member's total responsibility to the program. Total responsibility for a large number of students in a single course or supervision of course assistants can add as much to work assignments as an additional course. In making teaching assignments, departments must take into account not only the number of contact hours assigned, but also the number of students enrolled in those classes and, if teaching assistants are used, any additional supervisory responsibility.

d. A valuable part of the professional duties of some mathematical sciences department faculty members is the use of their expertise in providing professional consulting for their institution. The institution and the faculty member should place in writing an agreement describing exactly what the institution expects from the faculty member in these professional consulting activities that are not part of the workloads of all faculty members. The agreement should describe how the consulting activities will be evaluated, how they will be considered in the tenure and promotion process, and how they fit in the faculty member's work assignment. See also Guideline C.8.e.

e. The institution and the department should have a public written policy on the amount of time that a full time faculty member can spend during the academic year on outside activities for compensation.

6. ADEQUATE STAFFING LEVELS

Department staffing levels should be sufficient to allow personal interaction between student and instructor to occur in all courses, to give tenure-track faculty adequate time to meet tenure expectations, to allow faculty to engage in scholarship consistent with departmental expectations, and to meet work assignment expectations similar to those of peer departments at comparable institutions. Many mathematical sciences programs today tend to have too large a percentage of part-time faculty, and, over time, should convert part-time positions into full-time positions. This fosters the participation of a greater percentage of faculty in the work of the department.

7. SECURING AND SUSTAINING A DIVERSE FACULTY

a. The mathematical sciences are in constant need of being strengthened and replenished by drawing well-educated individuals from the broadest possible pool of talent. It is essential to widen the spectrum from which mathematical sciences faculty are drawn. Members of traditionally underrepresented groups, including women, minorities, the physically challenged and those from educationally deprived backgrounds, deserve special attention in this regard. The first step toward widening the talent pool from which new faculty are drawn is to make certain that all new positions are advertised in places seen by all potential faculty members.

b. Hiring decisions are only first steps in achieving and sustaining a diverse faculty. Subsequent issues of faculty development are equally important.

   i. A department should maintain an atmosphere that welcomes all people who seek to work and study in the mathematical sciences disciplines in that department.

   ii. Departments have a special responsibility to newly hired faculty from historically underrepresented groups (see above) to protect them from excessive demands on their time and energy from advising and committee service that go beyond what is expected of other faculty members.

   iii. Departments recruiting faculty from historically underrepresented groups must accept the responsibility for nurturing the professional growth and advancement of these faculty, especially during their early years of employment, in order to insure long-term diversity rather than short-term.

   iv. Departments should be on record as endorsing and enforcing the institution-approved personnel policies, including policies on non-discrimination and sexual and other harassment.

8. FACULTY EVALUATION AND REWARDS

a. The department should have written procedures for evaluating its faculty members on the basis of teaching, scholarship, and service. These departmental procedures should be made available to all departmental faculty and should be reviewed periodically.

b. Tenure-track, non-tenured faculty should be counseled annually as to progress toward tenure.

c. "Departments should use the best available methods, imperfect though they may be, for evaluating teaching, scholarship, and service while also seeking to develop better methods of evaluation." See "Guiding Principle V" on page 35 in "Recognition and Rewards in the Mathematical Sciences," [26].

d. "Every institution and department should work to develop efficient, robust, reliable, and trusted measures of teaching effectiveness. These could include peer evaluation, surveying of students from current and previous semesters (graduating seniors or alumni, for example), studying student achievement in subsequent courses, reviewing syllabi and examinations, and other techniques. " See "Discussion" to "Guiding Principle V" on page 35 in "Recognition and Rewards in the Mathematical Sciences" [26]. Also see the Mathematical Sciences Education Board document, "Report of the Task Force on Teaching Growth and Effectiveness," [39].

e. In accordance with departmental mission and priorities, some consulting and other professional activities may advance the scholarship and teaching of faculty members and the department. Consulting and other professional activities may fit into the category of teaching or scholarship and in that case should be evaluated accordingly, or such activities might be evaluated as a separate category, with correspondingly less emphasis on other categories. Supervision processes and evaluation procedures for formal consulting activities should include the monitoring of faculty progress in maintaining and improving the quality of these activities. Evaluation criteria and procedures for consulting activities must be a part of a written agreement among the faculty member, the department, and the appropriate dean.

f. Professional expectations vary considerably among the mathematical sciences disciplines. When a department has faculty members from several disciplines, it is particularly important that there be a mutually accepted, written statement concerning expectations for the faculty members in the areas of teaching, scholarship, and service, and, if relevant, consulting. It is important that the agreed upon expectations statement be the basis for personnel decisions. Departments should consult position papers of various professional societies in preparing such expectations statements. Furthermore, if the department has only one or two faculty members in a discipline, it should seek outside persons to serve as advisors for departments and mentors for these isolated faculty members early in their careers. If such outside advisors or mentors are used, it is important that they and the department give the same messages to the faculty member about departmental and institutional expectations. Professional societies can identify senior faculty members who are willing to serve as outside advisors and mentors.

g. "Each department must develop a rewards system consonant with its own mission and the mission of the institution. In formulating a rewards structure, each department must analyze who its constituencies are, what they need from the department, and whether those needs are being met." See "Discussion" to "Guiding Principle VI," p. 37, in "Recognition and Rewards in the Mathematical Sciences," [26].

9. SUPPORT STAFF

Clerical and technical staff should be sufficient to support the teaching and scholarly activities of the department. It is particularly important to have adequate technical staff to maintain computers used by students, faculty, and clerical staff. Faculty should not be expected to provide computer support for the department.

D. Curriculum and Teaching

1. CURRICULUM PLANNING AND REVIEW PROCEDURES (SEE SECTION B, ITEMS 1, 2, 3)

   a. The department should have the primary responsibility and most influential voice in setting the placement policies, the prerequisites or co-requisites, the course content, and the exit competencies for the department's courses. See Guideline F.1.a.

   b. Departments should discuss with client departments plans to change mathematical sciences courses or programs in ways that would have significant effects on academic programs in the client departments. This consultation should continue throughout the process of making the change. See Guideline F.1.a.

   c. There should be established procedures for periodic review of the curriculum. These reviews, which should be a part of the duties of faculty assigned by the department, should include careful scrutiny of course syllabi, prerequisites, and textbooks. These reviews should examine the curriculum in the context of the departmental goals and institutional mission. They should include consideration of the curriculum's relevance and appropriateness for the students being served. Effective reviews often lead to revision, addition, or deletion of courses.

   d. Many courses within mathematical sciences programs are organized with a sequence of prerequisites. Course prerequisites should be clearly stated and equitably enforced. A current syllabus for each course should be on the web and on file for review by faculty colleagues and by students. Catalog course descriptions should be kept up-to-date. Departments should take the necessary steps to ensure that all sections of a given course are consistent in content, use of technology, focus, and rigor.

   e. In cases where the department regularly teaches students who transfer from two-year colleges, the department should cooperate with those two-year colleges in facilitating student transfers. Mathematical sciences faculty members at the institutions should work together to ensure compatibility of appropriate courses, and course equivalencies should be published. Faculty should ensure that the courses taught at the two- and four-year colleges are consistent in content, technology, focus, and rigor.

   f. The development and review process for courses that support other programs should involve faculty members from those programs. In addition, informal contacts with faculty from other departments can provide useful information concerning the mathematical sciences courses that their students must take. Working collaborations with faculty colleagues in departments of education must be established to strengthen the programs that prepare teachers of school mathematics.

   g. In cases where a department offers a course or courses in a particular discipline, but does not have a faculty member with expertise in that discipline, the department should take special care to consult the curricular guidelines of the relevant professional society in that discipline.

2. CURRICULUM ACCESS AND PEDAGOGY

   a. The mathematical sciences curriculum should be responsive to the needs of the department's students. Course and program offerings should provide suitable academic challenge and should be based on the expectation that all students can learn mathematics. The spectrum of beginning courses should be broad enough to offer appropriate choices and placement in mathematics for all students entering the institution.

   b. Departments must be provided with the resources necessary to deliver high quality teaching that includes the opportunity for students to interact frequently and nontrivially with their instructors. Departments should facilitate these personal interactions by avoiding the use of large lecture settings that require students to become passive audiences. The best way to encourage active student-faculty interactions and to enable faculty to give students individual attention is to provide a small-class environment with fewer than thirty students in each section. Also with restricted class size, faculty members gain flexibility to adopt a teaching style that best fits both the material to be learned and their students' needs.

   c. The instructional staff assigned to each course should be sufficient to allow for regular and frequent feedback to students about their progress. Feedback from instructors should take various forms, such as critical reviews of short quizzes and hour tests, comments and suggestions for homework or writing assignments, and critiques of students' presentations of projects and contributions in seminars. Interaction in classes, mathematics laboratories, and workshops provides additional feedback. Instructors should consider all of these forms of evaluation not just as evaluation of the students but also as information that can be used to improve their teaching. Instructors can gain information for improving their teaching also from student journals and mid-semester questionnaires.

d. Courses which are required in a student's program of study but have a history of low enrollment should be scheduled and taught at least once every two years regardless of the low enrollment. Courses that are not scheduled at least every two years should not be listed in the college catalog.

3. QUANTITATIVE REASONING FOR COLLEGE GRADUATES

In 1996, the MAA Board of Governors approved the report, "Quantitative Reasoning for College Graduates: A Complement to the Standards," [15]. The summary and preface of this report may be found in Appendix A of this document. The text of the full report may be found at the MAA Online Web address http://www.maa.org/past/ql/ql_toc.html.

a. Mathematical Sciences departments should assume the responsibility of actively developing and promoting within their institutions quantitative literacy general education requirements for all undergraduates.

b. These quantitative literacy requirements

   i. Should be consistent with the Report, "Quantitative Reasoning for College Graduates: A Complement to the Standards,"

   ii. Should emphasize teaching students to use mathematical methods to solve real-world problems, and

   iii. Should involve courses at both the lower and upper division levels.

The report, "Quantitative Literacy: Why Numeracy Matters for Schools and Colleges," [48] helps to provide a rationale for the role of mathematics in quantitative literacy programs.

4. PROGRAM RECOMMENDATIONS OF PROFESSIONAL SOCIETIES

a. The mathematical sciences bachelor's degree program should be consistent with the current recommendations of the MAA Committee on the Undergraduate Program in Mathematics (CUPM) Guidelines. Departments should provide for majors the experiences described in the section, "Completing the Major," of the CUPM Report [17]. Programs with no curricular track that conforms to the CUPM guidelines should be justified by a detailed and persuasive rationale for departing from those guidelines. A summary of the CUPM Report comprises Appendix B of this document. The full report has been reprinted in "Heeding the Call for Change: Suggestions for Curricular Action" [52], pp. 225-247. Those who develop or deliver statistics major, minor, or concentration programs within mathematical sciences programs or departments should know the recommendations contained in the American Statistical Association report, "Curriculum Guidelines for Undergraduate Programs in Statistical Science," [3].

b. If the institution offers a program of study leading to certification of elementary or secondary mathematics teachers, that program should be consistent with the current guidelines of the MAA Committee on the Mathematical Education of Teachers (COMET), "A Call for a Change: Recommendations for the Mathematical Preparation of Teachers of Mathematics," [28]. In addition, the faculty who develop and deliver the program should know the recommendations contained in the Conference Board on Mathematical Sciences report, " The Mathematical Education of Teachers," [18] (the CBMS MET Report) and in the National Council of Teacher of Mathematics (NCTM) publication, "Principles and Standards for School Mathematics,"[35]. A summary of the COMET Report is contained in Appendix C of this document. Those who develop and deliver two-year college school teacher preparation programs should know the recommendations contained in the National Science Foundation report, "Investing in Tomorrow's Teachers: The Integral Role of Two-Year Colleges in the Science and Mathematics Preparation of Prospective Teachers," [40].

5. RESEARCH IN TEACHING AND LEARNING

Departments should be aware of the results of research on teaching and learning in the mathematical sciences, and they should make use of those results in improving instruction. Such research can provide a useful framework for such pedagogical matters as what students know and can do, how they develop their understanding of mathematical concepts, how they solve problems, how various kinds of mathematics teaching affects learning, and how students read proofs. No one method of instruction is optimal for all students, for all faculty members, or for all subject matter. Departments should encourage and assist faculty members who investigate, try out, and evaluate alternative teaching techniques that show promise in helping some students be more successful in learning in the mathematical sciences. See also Guideline C.2.e.ii.

6. IMPACT OF TECHNOLOGY

   Mathematical sciences departments should employ technology in ways that foster teaching and learning, increase the students' understanding of mathematical concepts, and prepare students for the use of technology in their careers or their graduate study. Where appropriate, courses offered by the department should integrate current technology. The availability of new technological tools and their pervasive use in the workplace have the potential for changing both the curriculum and the way that the mathematical sciences can and should be taught. See also Guideline C.2.e.iii.

   a. Departments should review and adjust the curriculum to reflect the expanded use of technology in each discipline and in the workplace.
   b. In courses where the use of modern technology will enhance student learning, departments should adopt methods of teaching mathematical sciences courses that make full use of appropriate current technology. These methods include laboratory sessions and assignments using computer software or graphing calculators, electronic communication with students, demonstrations in class using projection equipment, group activities fostered by technology, and use of the Internet.
   c. The student activities and experiences related to technology should be designed primarily to enhance the learning of mathematics and may serve to introduce the students to mathematically related technology. Special emphasis should be placed on giving prospective teachers the experience of learning mathematics using, or adapting, methods practiced in the schools and on educating these prospective teachers to be leaders in the effective use of technology in the schools.
   d. Faculty should consider the many different ways to employ technology in order to foster interaction among instructors and students.
   e. Departments should develop a general policy for assessment of student work that acknowledges the role of technology in the curriculum. In particular, departments should
      i. Adopt a policy of testing students in the way that they actually do their coursework. That is, if students regularly use graphing calculators or computer software for assignments, then the same facilities should be available during tests. If desired, students may be tested separately for computational facility and particular facts without the use of technology.
      ii. Adopt a policy on assessment of technology-based student projects and assignments.

E. Resources

1. FACULTY RESOURCES

   All faculty should be furnished with the resources (computers, computer software, and travel funds, for example) necessary for them to perform the teaching and the scholarly activities they were hired to do. It is critical in this regard that new faculty have access to these resources when they begin work in their faculty positions.

2. OFFICE SPACE

   All full-time mathematics faculty members should have private offices. Each part-time faculty member should have a desk and office space that allows confidential conferences with students outside the classroom.

3. CLASSROOM EQUIPMENT

   Classrooms should be equipped with such traditional teaching aids as adequate board space and projector equipment and screens. Other teaching aids such as computer and internet access, CDROMs, slide and video projection equipment, and computer projectors and monitors should be available as needed.

4. COMPUTER RESOURCES

   a. The department's access to computer resources for teachers and students should be consistent with the MAA policy statement contained in Appendix D.
   b. The department faculty should have high-speed access to the Internet. This access should enable faculty to quickly download graphics and data.

5. INFORMAL GATHERING SPACE FOR MAJORS

   There should be dedicated space for use by mathematical sciences majors for conversation and study. It is desirable that this space be near faculty offices to allow opportunity for frequent contact between students and faculty.

6. LIBRARY FACILITIES

   a. Library holdings should include the publications labeled "Essential," "Highly Recommended," or "Recommended," at the MAA Internet page, "Basic Library List" for undergraduate mathematics. The Internet address for the page is http://www.maa.org/data/bll/home.htm.
   b. Library holdings should be sufficient to provide mathematics enrichment materials for undergraduate student projects and to meet the scholarly needs of the program faculty. If specific library materials are not available on site, then they should be readily available through a process of interlibrary loan.
   c. The institution's libraries should be staffed, scheduled, and located in such a way that their mathematical sciences holdings are readily available to all faculty members and students.
   d. Library holdings of books and periodicals in the mathematical sciences should be reviewed periodically by committees, which include representatives of the mathematical sciences departments.

F. Students

1. ADVISING

   a. Departments should have established policies and procedures for placement in introductory mathematical sciences courses. It is important that these policies be well understood and disseminated across the institution.

   b. The mathematical sciences faculty, admissions personnel, and other freshman/sophomore advisors should periodically review the effectiveness of these placement procedures for entering freshmen.

   c. Advisement of transfer students should involve cooperative efforts of mathematical sciences faculty of both sending and receiving institutions.

   d. Departments should make information available to all students about their educational programs in the mathematical sciences through printed and internet media (such as an advising handbook) and through informal and formal advising.

   e. Departments should provide majors and other students with information about careers in the mathematical sciences and should make qualified students aware of further educational opportunities. In particular, qualified students should be encouraged to take advantage of summer programs at other institutions including programs that provide undergraduate research experience.

   f. Every student who declares a major in the mathematical sciences should be assigned an advisor from the mathematical sciences faculty. Advisors should take an active role in meeting regularly with their advisees, particularly with students who seem reluctant to ask questions. The CUPM Statement on Advising, contained in Appendix E, provides a model for departments to follow in their advising programs.

2. BROADENING THE STUDENT BASE IN THE MATHEMATICAL SCIENCES

   The nation's work force is becoming increasingly dependent on substantial mathematical preparation, and demographics indicate that women and minorities constitute a growing percentage of new entrants to the work force. Department faculty must address a changing student body whose experiences, cultural backgrounds, and learning styles may be significantly different from those of current mathematical sciences faculty members.

   It is essential to ensure that women, underrepresented minorities, and students from educationally deprived backgrounds are encouraged both to study the mathematical sciences at all levels and to become part of the mathematical sciences community. Appropriate programs and courses in the mathematical sciences should be available to all students who are admitted to the institution and have an interest in mathematics. Further, in both curricular and co-curricular activities, there should be concentrated efforts on the part of the department's faculty directed to assuring that courses, programs, and the departmental climate are inviting and supportive to all students regardless of their gender or cultural background.

   To achieve these goals, it is recommended that departments:

   a. Have explicit policies and related practices to attract and retain members of groups currently underrepresented in the mathematical sciences;

   b. Distribute career information on mathematical sciences-based careers that actively encourages these choices by students, especially minorities and women;

   c. Develop policies and articulation agreements with two-year colleges to facilitate student transfers between two-year and four-year institutions;

   d. Work to increase the presence of women and minorities in academia and other mathematical sciences-based careers by encouraging qualified women and minority students to pursue graduate study in the mathematical sciences;

e. Initiate intervention projects whose participants include pre-college students in minority communities and work with predominantly minority organizations to encourage persistence of minority students in their study of the mathematical sciences;

f. Include more opportunities for student interaction as might take place in mathematical sciences laboratories, tutorial sessions, or structured small group learning sessions;

g. Ensure that all departmental facilities and activities are accessible to students who are physically disadvantaged; and

h. Enforce university or departmentally approved policies, including those addressing sexual harassment and discrimination, as they apply to relationships among students and between students and faculty. If relevant policies do not already exist, departments should seek, through appropriate governance channels, to establish the necessary policies needed to foster positive departmental atmospheres.

3. CO-CURRICULAR ACTIVITIES

a. Department faculty should be involved with undergraduates in co-curricular activities designed to create an atmosphere of inclusion and cohesiveness among mathematical sciences majors and a sense of participation in the department. This atmosphere should be attractive to all majors but especially to women and those of diverse cultural backgrounds. Mathematical sciences clubs, honorary societies such as Kappa Mu Epsilon and Pi Mu Epsilon, MAA Student Chapters and student chapters of other professional societies are possible options. Teams for the Putnam and Modeling competitions and scheduled departmental social activities that include undergraduates are other such activities.

b. Special colloquia appropriate for undergraduates should be regularly held.

c. Departments should encourage faculty to work with undergraduate students in research projects.

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APPENDIX A

QUANTITATIVE REASONING FOR COLLEGE GRADUATES: A COMPLEMENT TO THE STANDARDS

SUMMARY

What quantitative literacy requirements should be established for all students who receive a bachelor's degree? Over the years, the Mathematical Association of America (MAA) has approached this question in various ways, most recently by establishing, in 1989, a Subcommittee on Quantitative Literacy Requirements (henceforth called the Subcommittee) of its Committee on the Undergraduate Program in Mathematics. The work of the Subcommittee has been similar in some respects to the efforts of the National Council of Teachers of Mathematics (NCTM) that led to its celebrated Curriculum and Evaluation Standards for School Mathematics (1989) and related publications. The recommendations from the Subcommittee can be considered to complement those in the Standards. They also should be viewed as a reasonable extension of a Standards-based high school experience to the undergraduate level.

The Subcommittee began with the perception, supported by many recent studies and reports, that general mathematical knowledge among the American people is in a sorry state. It assumed that colleges and universities would welcome some suggestions on what they might do about the situation.

The discussions and investigations conducted by the Subcommittee led to four primary conclusions. The conclusions embody a vision that goes well beyond present practice in most places.

Conclusion 1. Colleges and universities should treat quantitative literacy as a thoroughly legitimate and even necessary goal for baccalaureate graduates.

Many authoritative mathematical and other groups have affirmed the importance of quantitative, or mathematical, skills in the population at large. These skills are valuable in various ways (this report lists nine), e.g. in daily life, further education, careers, and overall citizenship. To some degree these skills are acquired by the end of secondary education, but the post-secondary experience should reinforce what has been learned in school and go beyond. Thus the Subcommittee's concern has been not with quantitative literacy in general, but with quantitative literacy for college graduates, which naturally should differ in both depth and quality from that expected of high school graduates.

Conclusion 2. Colleges and universities should expect every college graduate to be able to apply simple mathematical methods to the solution of real-world problems.

Rote and passive learning of mathematical facts and procedures is not enough. Educated adults should be able to interpret mathematical models, represent mathematical information in several ways, and use different mathematical and statistical methods to solve problems, while recognizing that these methods have limits. These elements extend those in the ideal of "mathematical power" presented in the NCTM Standards, which include "methods of investigating and reasoning, means of communication, and notions of context." At the same time, these goals seem attainable.

Conclusion 3. Colleges and universities should devise and establish quantitative literacy programs each consisting of foundation experience and a continuation experience, and mathematics departments should provide leadership in the development of such programs.

A required course or two is not sufficient. A student becomes quantitatively literate through a broad program that instills certain "long-term patterns of interaction and engagement." The program, the central idea of these recommendations, starts with a "foundation experience" into which students are appropriately placed and in which a carefully chosen course or two can raise entering students to a level of proficiency where they can benefit from the next phase, which is the "continuation experience."

In the continuation phase, later in their undergraduate programs students exercise and expand the elements of quantitative literacy they have already learned in the foundation experience and elsewhere. This phase is made possible by a framework of mathematics across the curriculum, an array of courses (both within and outside mathematics) and other educational experiences designed, in content and style, to contribute to the strengthening of quantitative literacy. The mathematics should be taught in context. Instructional materials should be current, practical, and conducive to active student involvement. Writing, student collaboration, and thoughtful use of instructional technology all have potentially important places. The program may also include the provision of mathematics clinics and other such resources.

In the course of these efforts, the needs, backgrounds, and expectations of people who in the past have tended to have special problems with mathematics should not be overlooked. Indeed, a well-designed quantitative literacy program may be of exceptional benefit to those persons who have special difficulties with mathematics.

Conclusion 4. Colleges and Universities should accept responsibility for overseeing their quantitative literacy programs through regular assessments.

A quantitative literacy program should be managed watchfully. At appropriate times and in appropriate ways, the results should be evaluated so as to obtain enlightened, realistic guidance for improvement. Evaluation methods should reflect course goals and teaching methods used, and besides pointing to possible improvements in the program can themselves be educationally beneficial. In particular, the evaluation methods should involve clearly applications-oriented tasks.

[The report concludes with five appendices including references, a list of topics on which one might base a reasonable syllabus, brief descriptions of some existing foundations courses, a questionnaire for assessing attitudes toward mathematics, a list of problems related to minimal competency, a set of project ideas, several scoring guides, and comments on approaches to quantitative literacy for two specific majors.]

Committee on the Undergraduate Program in Mathematics. "Quantitative Reasoning for College Graduates: A Complement to the Standards". A Report of CUPM. Washington, D.C.: Mathematical Association of America, 1996.

APPENDIX B

THE UNDERGRADUATE MAJOR IN THE MATHEMATICAL SCIENCES

SUMMARY

This CUPM report on the undergraduate major in the mathematical sciences describes a curricular structure with fixed components within which is considerable latitude in specific course choices. Combined with specialized curriculum concentrations or tracks within the major, this structure provides flexibility and utility. The structure involves both specific courses (e.g., "linear algebra"), and more general experiences (e.g., "sequential learning") derived through those courses. By making appropriate choices within components, students can obtain a strong major for prospective secondary teaching or for graduate school preparation.

The component structure with tracks is typical of the pattern of many of today's undergraduate mathematical sciences departments in that it allows many curricular choices. Seven components form the structure of the mathematical sciences major:

A. Calculus (with differential equations)

B. Linear algebra

C. Probability and statistics

D. Proof-based courses

E. An in-depth experience in mathematics

F. Applications and connections

G. Track courses, departmental requirements and electives

In addition to courses and components, the mathematical sciences major should also involve a variety of other types of experiences and activities that are, in some cases, "co-curricular." Several supportive activities are specifically cited as contributing to students' self-confidence and ability to work with others: integrative experiences, communication and team learning, independent mathematical learning and structured activities.

The statements of philosophy in the report embody educational principles that can lead to an enriching educational experience and the recommended program structure provides a flexible vehicle for fulfilling those principles. One underlying tenet, however, transcends the particular form of curriculum implementation: It is only by requiring substantive achievement of our students that we will be able to produce the sort of quantitatively expert individuals who are going to be the mainstay of the discipline and of society for the next century."

Committee on the Undergraduate Program in Mathematics. "The Undergraduate Major in the Mathematical Sciences". A Report of CUPM. Washington, D.C.: Mathematical Association of America, 1991.

APPENDIX C

A CALL FOR CHANGE

RECOMMENDATIONS FOR THE MATHEMATICAL PREPARATION OF TEACHERS OF MATHEMATICS

SUMMARY

"A Call for Change" is a set of recommendations for the mathematical preparation of teachers from the Mathematical Association of America. The document, recognizing that there are complex interactions among the teacher, the mathematics content being taught, and the students, speaks to recommended changes in the teaching and learning of mathematics by teachers. In this sense, it should be considered together with NCTM's document, "Professional Standards for Teaching Mathematics." This latter document addresses means to close the gap between recommended ideals of teaching mathematics and the reality of mathematics education in the schools today.

"A Call for Change" has four main sections:

Standards common to the preparation of mathematics teachers at all levels.

Standards in this section encompass the preparation recommended for mathematics teachers in order that they:

- principles;
- communicate mathematics accurately, both verbally and in writing;
- modeling;
- understand and use calculators and computers appropriately in the teaching and learning of mathematics;
- appreciate the development of mathematics both historically and culturally.

Standards for Teachers at the Elementary Level (K-4)

A core of experiences described with four broad standards on

- nature and use of number;
- geometry and measurement;
- patterns and functions;
- collecting, representing, and interpreting data.

Standards for Teachers at the Middle Grades Level (5-8)

At this level, the core experiences are described through five standards:

- number concepts and relationships;
- geometry and measurement;
- algebra and algebraic structures;
- probability and statistics;
- concepts of calculus.

Standards for Teachers at the Secondary Level (9-12)

The equivalent of a major in mathematics, but one quite different from that currently in place in most institutions, is recommended at this level. It is expected that the courses offered by departments of mathematics include the experience necessary to meet the common standards listed above.

The Standards given in "A Call for Change" describe broad knowledge and understanding of mathematics.

It is not the intention that a given standard describes the content of a single college-level mathematics course.

Why is there a need for change?

Mathematics continues to be a dynamic, changing discipline. There is new mathematics that can be exciting for young people to learn and technology provides new approaches for teachers to engage students in the teaching and learning of mathematics. The mathematics preparation of teachers must adapt to these changing realities.

Committee on the Mathematics Education of Teachers. "A Call for Change: Recommendations For The Mathematical Preparation Of Teachers Of Mathematics". James R. C. Leitzel, Editor. MAA Notes and Reports Series. Washington, D.C.: Mathematical Association of America, 1991.

APPENDIX D

PROVIDING RESOURCES FOR COMPUTING IN UNDERGRADUATE MATHEMATICS

Computers and calculators are transforming the world in which students will live and work. Moreover, technology is changing the way mathematicians work and teach, as well as enhancing the potential for learning mathematics. These changes present both opportunities and challenges for college and university departments of mathematics.

The Mathematical Association of America urges colleges and universities to respond aggressively to the changing needs of their students. In particular, all mathematics departments should prepare students to use mathematics in a technological environment. To achieve this objective, faculties, departments, and institutions must work together:

- To ensure that all students have sufficient access to computing resources appropriate to the needs of their mathematics courses.
- To provide mathematics faculty members effective access to appropriate computing equipment.
- To provide faculty members with adequate time, opportunity, and professional incentives to use technology effectively.
- To provide the resources required for a computer enriched teaching environment.
- To provide effective technical support to departments of mathematics.

Faculties and administrations must together devise appropriate local solutions to the many problems that arise as mathematics departments adapt to the new role of calculators and computers. These problems include hardware (cost, access, location, ownership), software (effectiveness, licensing, hardware environments), space (laboratories, classrooms, offices); personnel (installation, maintenance, consulting); management (central vs. distributed); and work loads (course development, laboratory instruction).

Further information on development of effective calculator and computer environments for undergraduate mathematics can be obtained from The Mathematical Association of America, 1529 Eighteenth Street, NW, Washington, DC 20036.

Statement by the Board of Governors of the Mathematical Association of America, January 15, 1991, San Francisco, California

APPENDIX E

ADVISING

Unlike an earlier, simpler day when all mathematics majors took the same sequence of courses with only a few electives in the senior year, the typical undergraduate mathematical sciences department today requires students to make substantial curricular choices. As a result, departments have advising responsibilities of a new order of magnitude. Students need departmental advice as soon as they show interest in (or potential for) a mathematics major. Advisors should carefully monitor each advisee's academic progress and changing goals, and together they should explore the many intellectual and career options available to mathematics majors. Career information is important. If a "minor" in another discipline is a degree requirement or option, then achieving the best choice of courses for a student may necessitate coordination between the major advisor and faculty in another department.

Advisors should pay particular attention to the need to retain capable undergraduates in the mathematical sciences pipeline, with special emphasis on the needs of under-represented groups. When a department offers a choice of several mathematical tracks within the major, advisors have the added responsibility of providing students with complete information even when students do not ask many questions. Track systems may lead students to make lifetime choices with only minimal knowledge of the ramifications; therefore, departments utilizing these systems for their majors must assure careful and timely information. One requisite of an individualized approach to advising is that each advisor be assigned a reasonable number of advisees.

Committee on the Undergraduate Program in Mathematics. "The Undergraduate Major in the Mathematical Sciences ," Page 5. A Report of CUPM. Washington, D.C.: Mathematical Association of America, 1991.

APPENDIX F

TASK FORCE TO REVIEW THE 1993 MAA GUIDELINES FOR PROGRAMS AND DEPARTMENTS IN UNDERGRADUATE MATHEMATICAL SCIENCES

Donald L. Bentley, Pomona College, Claremont, CA

Sylvia T. Bozeman, Spelman College, Atlanta, GA

Chair: **John D. Fulton**, Virginia Polytechnic Institute and State University, Blacksburg, VA

Wanda L. Garner, Chair, Division of Math, Science and Engineering, Cabrillo College, Aptos, CA

Nancy L. Hagelgans, Ursinus College, Collegeville, PA

David J. Lutzer, College of William and Mary, Williamsburg, VA

Dale H. Mugler, University of Akron, Akron, OH

Barbara L. Osofsky, Rutgers University, New Brunswick, NJ

Jimmy L. Solomon, Dean, Paulson College of Science and Technology, Georgia Southern University, Statesboro, GA

Ann E. Watkins, California State University, Northridge, Northridge, CA

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P.O. Box 90973

Washington, DC 20090-0973

Tel: (800) 331-1622

Fax: (301) 206-9789

E-Mail: maahq@maa.org

Website: www.maa.org