Working Group Reports

Task Force on Core Mathematics

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Transition from High School

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Enrollment in Entry Level Mathematics Courses

As can be seen in Appendix A, the number of students enrolling in mathematics courses in the fall of their freshmen year increased by 34% from 1998 to 2004 (from 3578 students to 4794 students). During the same period, the total number of incoming freshmen increased only 8.8%. In fall 1998, the total number of new freshmen was 5262 (see Appendix B) with 68% (3578 of 5262) enrolled in a mathematics course; in fall 2004, the total number of new freshmen was 5725, with 84% (4794 of 5725) enrolled in a mathematics course.

Appendix C shows enrollment of new freshmen in mathematics courses broken down by gender, ethnicity, and age. In fall 2004, 53.9% of incoming freshmen were female and 46.1% were male. With respect to enrollment and gender in courses with significant new freshmen enrollment, female students appear to be much more likely than male students to enroll in M105: Mathematics in Modern Society, M113: Elements of Calculus, M115A: Business Mathematics I, M160: Basic Statistics, M196A: Tutoring in the Schools, M197A: Basic Statistical Computation (taken currently with M160: Basic Statistics or M263), and M263: Introduction to Statistics and Biostatistics. Male students seem to be much more likely than female students to enroll in M109: College Algebra with Data Analysis, M120S: Calculus Prep, Self Study, M125: Calculus I, M129: Calculus II, M223: Vector Calculus, M250A: Calculus and Differential Equations I, and M254: Introduction to Ordinary Differential Equations. Males were somewhat more likely than females to enroll in M111: Plane Trigonometry, M124: Calculus I with Applications, and M215: Introduction to Linear Algebra. Overall, female incoming freshmen tended to be underrepresented in the more advanced mathematics courses.

In fall 2004, 14.34 % of the new freshmen were Hispanic, 3.18% were African American, 6.48% were Asian American, and 2.15% were Native American. Examining enrollment of new freshmen in mathematics courses (Appendix C), we found that African American, Native American and Hispanic students tend to be underrepresented in some of the more advanced courses taken by incoming freshmen – i.e., M125: Calculus I, M129: Calculus II, M215: Introduction to Linear Algebra, M223: Vector Calculus, M250A: Calculus and Differential Equations I, M254: Introduction to Ordinary Differential Equations, and M263: Introduction to Statistics and Biostatistics.

Preparation for and Placement into Entry Level Mathematics Courses

A large majority of incoming freshmen take a Mathematics Readiness Test (MRT) from the UofA; scores on MRTs are used to place the majority of incoming freshmen into appropriate mathematics courses (other means of placement include SAT and ACT scores, AP credit, and courses taken at other institutions). Two tests are given; MRT A assesses students' readiness for college algebra and MRT B assesses students' readiness for calculus. Of the 5725 new freshmen in fall 2004, 4288, or 75% were placed using an MRT (Appendix D, first table). Of the 4794 new freshmen who took a mathematics course in the fall of 2004, 4288, or 89% were placed using an MRT (Appendix D, first table). Since 1999, there has been a decrease in the percent of incoming freshmen who did not place into a course offered by the University of Arizona (i.e., students who placed into Pima 92 or Pima 122, again this is shown in the first table of Appendix D). However, the number of such students is still relatively large – over 28% in 2004. Over the same period, we find a slight increase in the percents of students placing into more advanced courses such as M124: Calculus I with Applications and M125: Calculus I. Comparing MRT placement data for all students to data for local area high school students (the second table in Appendix D), we find that students from local area schools are somewhat less likely to place into Pima 92 or 122 and somewhat more likely to place into the more advanced courses (i.e., calculus courses), although placement numbers vary widely across individual schools.

In fall 2004, 1491 of the 5725 new freshmen, or 26% had attended local area schools. Approximately one-fourth of these incoming freshmen took M110: College Algebra, while the numbers of students taking more advanced courses (i.e., M124: Calculus I with Applications, M125: Calculus I, and M129 Calculus II) varied greatly across school districts (Appendix E, Table 3 and 4). The highest numbers of incoming students came from Tucson Unified School District (TUSD), followed by students from private schools, and students from Amphitheater Unified School District. Examining the data for these and other districts shown in Appendix E, we see variation in both the mathematics courses taken prior to attending the University of Arizona (Appendix E, Tables 1 and 2) and the courses in which students enrolled at the UofA (Tables 3 and 4). Although we can glean something about students' mathematics backgrounds from examining the numbers of students enrolled in various courses in their high schools, a detailed analysis of the textbooks adopted by a district and the ways in which the textbooks and supplementary materials are used by district teachers would be needed to better understand the mathematical preparation of students prior to attending the University.

Transition Issues – High School Teachers' and Teacher Leaders' Perspectives

On August 30th, 2005 the Mathematics Department held a meeting with local area mathematics teachers, mathematics department chairs, and district mathematics specialists to gather perspectives on students' high school mathematical preparation and other issues related to students' success in entry-level mathematics courses or lack thereof. In addition, we solicited feedback via e-mail to collect additional information from individuals who attended the meeting and also from individuals who were not able to attend (name, title, and contact information for individuals who provided feedback can be found in Appendix F).

The information on students' mathematics preparation and transition to University of Arizona entry-level mathematics courses presented in this section of our report comes from a small, self-selected sample of local professionals. Thus, it should not be viewed as an *assessment* of students' experiences or needs. However, the feedback we collected can be helpful in understanding the wide range of issues impacting the transition process and suggesting areas that may be in need of attention. It is also important to note that we received feedback from individuals from a variety of schools and school districts. In attendance at the meeting were four mathematics department chairpersons (three from Tucson Unified School District (TUSD) high schools and one from Marana High School). In addition, the Amphitheater and TUSD mathematics coordinators, a representative from the Pima County Schools Superintendent's office, and teachers from Sunnyside High School and Flowing Wells High School participated in the meeting.

The following is a list of transition issues generated during the meeting and/or received via e-mail. Where possible, we have provided specific examples to clarify meanings.

- Higher level high school mathematics courses (i.e. pre-calculus and calculus) are often taught using traditional, lecture methods. This makes the transition to college courses difficult because some courses are taught using reform methods and most or all classes require more than following procedures for finding answers set forth by the instructor.

- Students need to be trained in how to move from a "traditional" to a "reformed" mathematics course and vice versa. Here, traditional means a course that is taught mainly through lectures in which the instructor or teacher does examples and then the students work through similar problems on their own. These courses often focus on learning and applying rules for manipulating symbols. Problems are typically decontextualized; i.e. the problems are not "word problems." In reform courses, students spend a significant amount of time investigating contextualized problems, using mathematics to model real-world phenomenon, and figuring out methods for finding solutions.

- There seems to be a gap between the content and teaching methods in high school pre-calculus courses and what students need if they are to be truly prepared to be successful in Calculus 1 at the University of Arizona. Part of this gap may be attributable to difference in expectations for student work and differences in instructional methods (see first bullet). Teachers suggest calculus instructors spend some time at the beginning of the course reviewing key concepts and setting expectations for the course.

- According to the teachers and teacher leaders with whom we spoke, students leave high school without the necessary logical and creative thinking skills needed for success at the university level. At the same time, we were told that students today do not exhibit the same skill level (i.e., knowing procedures to find answers to the point that they become automatic) as students did in previous decades. Some individuals attributed both of these problems to AIMS. Specifically, to prepare students for the state-mandated test, teachers spend more time reviewing basic skills and less time working on more advanced skills (e.g., procedures for finding answers to logarithmic or rational function problems). This leaves students entering the University of Arizona weak in some skills that university instructors may expect them to possess. In addition, according to the teachers and teacher leaders with whom we spoke, the AIMS test is skill-oriented, and pressure to prepare for AIMS takes time away from instruction that would help students build their problem-solving and logical and creative thinking abilities.

- Information on students' performance at the UofA could be very useful in helping teachers help students prepare for the transition to the university. The teachers and teacher leaders at the meeting requested data from the UofA on the mathematics course-taking and level of success in mathematics of their former students.

On the positive side, we were told that students today understand how to use graphing calculators and computers to learn and understand mathematics. Students have also been exposed to using and moving among multiple representations (tables of data, graphs, and equations). These are both areas upon which university instructors could build.

In addition to describing student transition issues, the teachers and teacher leaders in attendance at the meeting spoke very strongly about the benefits of mathematics department programs for teachers and the need for more such programs in the future. Almost every teacher in attendance at the meeting had participated in the University School Cooperative Program. The teachers said that this program had (1) improved their knowledge of higher level mathematics, (2) provided them with opportunities to teach the courses that their own high school students would someday take, and (3) supported them in making connections with university mathematics faculty and staff. Further, when they returned to their own classrooms, they brought back with them ideas about how to incorporate logical, critical, and creative thinking into their teaching. The teachers mentioned several other university programs which had benefited them including PRISM, the Teacher Recruitment and Retention Center, and Teacher Appreciation Day.

Transition Issues – UA Instructors' Perspectives

On September 13th, 2005 the Mathematics Department held a meeting with entry-level mathematics course instructors and other interested faculty members to gather information about students' mathematical knowledge and preparation, study skills, and course curricula and sequencing – in particular as these issues relate to students' ability to make the transition from high school to the UofA. We also solicited contributions via e-mail from individuals who were not able to participate in the meeting. The following list of issues and suggestions attests to the wide range of variables that come into play for students as they make the transition to university-level mathematics.

- Students are placed into courses through means other than Math Readiness Tests (MRTs). This leads to differences in students' levels of preparedness. For example, students who place into M124 (Calculus I) because they have obtained dual credit at their high schools may or may not be as prepared for calculus as students who have placed into the course through an MRT or SAT/ACT scores.

- The basic skills test for M124: Calculus I seems to be useful for predicting students' performance later in the course. Unfortunately, the test shows that the basic algebra and trigonometry skills of many of the students are fairly poor.

- Students who have had some experience with calculus in high school seem to have difficulty succeeding in their UofA calculus courses. One possible reason may be that students remember procedures (although they may not remember them correctly) for finding answers and want to use these "short cuts" while instructors want students to develop and utilize conceptual understanding.

- A troublesome gap exists between instructors' expectations and students' expectations and study habits. Instructors must convince students that there is a qualitative difference between the high school and the university and help them to develop good study skills; how can this best be done?

- High school mathematics teachers need more feedback than they are getting currently about the performance of their former students. We should also be working with high schools to ensure that their college preparatory programs are consistent with our needs and expectations.

- Skills necessary to succeed in calculus are not necessarily taught in M110: College Algebra or M120R: Calculus Preparation. Therefore, the policy of sending students back to these courses may not be particularly helpful. Should we restructure M120R to teach more calculus-relevant skills?

- Currently, the UofA precalculus course focuses on the concept of function and the college algebra course on a mix of concept understanding and skills. The placement test and drop-back policy should reflect these foci. The drop-back policy might benefit from being more flexible and case-dependent. In general, students would benefit from having more options to choose from after the first month of the semester.

- There is a trend across the nation to increase the number of students taking calculus in high school and algebra in middle school. One consequence of this trend may be that some students have gaps in their mathematical understandings that cause them difficulties in their university mathematics courses. We also need to examine the amount of content covered in courses here at the university for the same problem – i.e., the need to move through topics quickly can lead to superficial knowledge of procedures rather than deep knowledge of meanings. The lack of deep understanding of pre-requisite mathematical concepts and relationships and students' tendency to want to depend on superficially understood procedures to find answers was cited frequently as an issue with which entry-level instructors struggle to contend.

- Some students currently taking M110: College Algebra might be better served by taking M105: Mathematics in Modern Society; student advising should reflect this. Arizona State University is not allowing their students to satisfy general education requirements by taking a College Algebra course and we should consider whether to do the same at the UofA.

The last bullet listed above perhaps requires some further explanation. M105: Mathematics in Modern Society is an important entry level course taken by students from many different departments, primarily to satisfy a general education requirement. It is thus designed for students whose majors do not require any mathematics, for example theatre or studio art majors. With this in mind, the course does not cover abstract topics and uses only elementary high school mathematics. Some examples of applications discussed in the course are methods of ballot counting in elections, optimal routes for mail distribution, spiral forms in nature and their origin, and understanding simple statistics. When possible, historical contexts of the topics are discussed. Some students, however, choose M110: College Algebra rather than M105 to satisfy the general education requirement. This is sometimes done because the students are not sure if they will take more mathematics later and M110 may be required as a prerequisite for more advanced mathematics courses. In other cases, the students may feel more secure taking a subject with which they are familiar. In many situations, it would be better for the student to take a more meaningful course such as Mathematics in Modern Society, even if this would mean a risk of taking College Algebra in the future. In the interest of the students, advisers should recommend Mathematics in Modern

Society to more of their advisees. This will have two other positive consequences: (1) the average level of students taking M110 will increase and (2) fewer instructors will be required to satisfy the general education requirement of the same number of students, since M110 is a four-credit course and M105 is a three-credit course. For similar reasons, Arizona State University has recently adopted the policy that College Algebra does not satisfy the general education requirement.

Transition Issues – Students' Perspectives

This would seem to be a particular important area in need of further attention. We are not aware of any large-scale study conducted recently that could be helpful to us in assessing mathematics-specific transition issues from the perspectives of students. The relatively small number of students and teachers (who described to us information they received from former students) we have spoken to invariably mention language barriers; that is, although an instructor may have a basic proficiency with the English language, students may be unused to listening to English spoken with a particular accent or students may not feel the instructor is always able to understand or respond to their questions. What is unclear is the manner in which teaching methods and expectations for student behavior (when and how to ask question, amount of time one should spend on the course outside of class, the role of in-class time in the learning process) interact with students' perceptions and become attributed to "language." We wonder if differences in the cultures of instructors and students and the sometimes subtle ways these differences are experienced in classroom interactions, combined with the difficulties experienced in transitioning from high school to college more generally (such as expectation about the amount of time one should spend on homework), might account for much of what is attributed by students to "language." Regardless, this seems to be an issue which is continually raised in discussions about the transition from high school to college mathematics.

Life Sciences

Jim Cushing, Joceline Lega, Joe Watkins, Peter Wiles

Raising the level of training in quantitative skills for students majoring in the life sciences has become a national imperative for academic institutions. The Mathematics and Computer Science Panel Summary to the recent National Research Council study, *BIO 2010: Transforming Undergraduate Education for Future Research Biologists.* (http://www.nap.edu/books/0309085357/html/) states: "The panel suggested that all biology majors ... should be exposed to and develop a conceptual understanding for the idea of rate of change, modeling, equilibria and stability, structure of a system, interactions among components, data and measurement, stochasticity, visualizing, and algorithms.

The Mathematical Association of America, in responding with *Math & Bio 2010: Linking Undergraduate Disciplines* (http://www.maa.org/mtc/projectreport.html) "envisages a new educational paradigm in which the disciplines of mathematics and biology, currently quite separate, will be productively linked in the undergraduate science programs of the twenty-first century. As a science, biology depends increasingly on data, algorithms, and models; in virtually every respect, it is becoming more quantitative, more computational, and more mathematical."

This imperative is being manifested in several endeavors concerning both undergraduate and graduate education at the University of Arizona:

- A grant submission to the Howard Hughes Medical Institute to fund changes in math and biochemistry courses.
- A 2005 Arizona Board of Regents Learner-Centered Education grant application to develop Matlab learning modules to integrate fundamental mathematics concepts into a new Molecular and Cellular Biology 181R course.
- A 2004 Arizona Board of Regents Learner-Centered Education grant to develop web-based modules designed to help upper division students in biochemistry courses gain hands-on experience in applying mathematics to biological phenomena and situations.
- An extension of the Undergraduate Biology Research Program (UBRP) to students majoring in engineering, physics, mathematics or computer science. (http://ubrp.arizona.edu/interdisciplinary/default.cfm)
- The formation of a Quantitative Biology Consortium inside Bio5 (http://bio5.arizona.edu/research/research_qbc.php)
- The creation of the Graduate Interdisciplinary Program in Statistics with assistance from Bio5.

The life science working group received individual responses to our e-mail survey from at least 18 faculty members in the departments of Biochemistry, Ecology and Evolutionary Biology, Molecular and Cellular Biology, Physiology, Renewal Natural Resources, and Speech and Hearing Science, from the Arizona Research Laboratories and from the science education faculty. In addition, we conducted a on-line survey of the molecular and cellular biology faculty (see Appendix G), in which fifteen of its 17 members participated. We have summarized their contributions according to mathematical content areas.

Elementary Mathematics

Many faculty members were concerned about life science students' basic mathematical skills – performing arithmetical calculations, reading graphs, solving high school algebra problems and so on. This concern was expressed in a variety of ways – poor problem solving skills, in need of an intuitive number sense, inability to do symbolic reasoning, lack of appreciation of the practical application of mathematics, and lack of understanding of the importance of mathematical skills in the day to day work of a biologist. Several report a pervasive mathematics phobia. For example, the Molecular and Cellular Biology faculty report that even though the use of mathematics in biology has dramatically increased in the last few years, this fact is not reflected in the teaching of undergraduate biology, primarily because of the students' lack of mathematical knowledge. Others noted the inability to assume the algebra or calculus that students have previously learned.

Statistics

The need for training in statistics was the most frequently mentioned. Most saw an almost universal need for undergraduate life science majors in basic statistics – organizing and interpreting data, knowing inside out the logic of hypothesis testing, and basic inferential techniques like linear regression and analysis of variance. A variety of more advanced techniques were also mentioned, e.g., non-linear estimation techniques, Bayesian methods, and analysis of large data sets that arise, for example, in neuroscience, bioinformatics and microarrays.

Probability

The suggestion for a course in probability theory was the second most frequent suggestion. The respondents noted that probabilistic reasoning gained through coin tossing and other elementary concepts was important to understand random events in disciplines that range from genetics, to cell biology and ecology. Others want such a course to move onto more advanced topics like the understanding of the central limit theorem, how probability distributions arise in practice, and an introduction of Markov chains.

Differential equations

The use of ordinary differential equations was most frequently mentioned by the ecologists and biochemists, although faculty from other disciplines recognized its importance in undergraduate training. Those who stressed the importance of differential equations in undergraduate education expressed the desire that the course contents have analytical, computational, and qualitative techniques.

Matrix algebra

Beyond and elementary understanding of what matrices are and their basic algebraic properties, respondents saw matrix or linear algebra as needed for a solid understanding of other mathematical topics, notably multivariate statistics and ordinary differential equations. In this regard, it should be noted that calculus was not frequently mentioned explicitly. In the way calculus was discussed, this seemed to signify, for those disciplines that presently require calculus, the acknowledgment of the centrality of the subject as a part of mathematical training for life scientists.

Finite Mathematics

With the rise in importance of bioinformatics, the need for combinatorial methods and graph theory has become more prominent.

Computation

Educational needs in computation are seen as necessary from a variety of perspectives. Most basically, several call for a basic understanding of an algorithmic approach to problem solving. Beyond that, we heard of the need to handle large data sets using statistical software like SAS or R, to use publicly accessible databases, to write simulations and do numerical analysis using, for example, Matlab, to perform symbolic manipulation using, for example, Mathematica, and to be able to write scripts, for example using perl, java or C. Several called for a course based on Matlab.

Modeling

Much of the discussion was thought of as groundwork for the central skill in quantitative training for life scientists – creating quantitative models. Thus, the scientists who responded to our survey want students to understand the quantitative aspects of the question under study, have the mathematical skills to analyze and build a model. They then would like to have the student be able to follow up with the appropriate computational technique—statistical inference, or computer simulation and to have this form a central component of their scientific work.

Physical Sciences and Engineering

Ildar Gabitov, Robert Indik, David Lomen, Shankar Venkataramani

This portion of the report consists of notes on various meetings held by members of the working groups. The group was not able to talk to all departments, so it is recommended that the Task Force consider soliciting further information.

Chemistry

Report from a meeting between Robert Indik, David Lomen, the Chemistry department head of Chemistry, and five other Chemistry professors (teachers of freshman chemistry, organic, and physical chemistry) in early October.

The beginning chemistry class uses mostly linear functions and uses basic algebra in balancing equations, computing amounts of products of reactions etc. They also do error analysis and linear fits to data. They report that enforcing an adequate score on the MRT as a prerequisite to freshman chemistry has been very beneficial.

As far as physical chemistry is concerned, the lack of knowledge of differential equations hampers their coverage of quantum mechanics. (They only require three semesters of calculus, and not differential equations.)

They were very happy with the experiment we did with a special section of Math 223 where we replaced the last half of the course (the material on multi dimensional integration) with material on differential equations. They would very much like to have special sections with that material for their students again. They estimate from 30-60 students each semester, but realize it is difficult to find a time when they all could take that section.

In general, the chemistry department is quite pleased with what we cover in our calculus sequence for their students, but would be much happier with special sections of Math 223.

Aerospace and Mechanical Engineering

David Lomen met with the undergraduate committee of the department of Aerospace and Mechanical Engineering the last week in October.

They teach a junior level course in mathematical methods for engineers that is required of all of their majors. They have about 60 students each semester. The content of this course is similar to that of our Math 322, with the exception of their spending considerable time on linear algebra, and none on Laplace transforms. They would like to require their majors to take Math 322 as a requirement, but not with the current syllabus.

As optical engineering professors would like to modify the syllabus for Math 322 (currently required for their majors), it seems reasonable to have representatives from optical engineering, aerospace and mechanical engineering, and electrical and computer engineering (who currently require Math 322) meet to see if they can agree on a common syllabus. As we do not currently have the staff to teach two more sections each semester, this would be an exercise on future feasibility, given additional resources. As noted in the report on the meeting with Optical Sciences, optical engineering is willing to give financial support to a special section of Math 322 geared to their students.

Engineering

Report on a meeting with Engineering Undergraduate Dean Jeff Goldberg, Mark Riley (ag), Ted Laetsch, Shankar Venkataramani, and Bill McCallum

Mathematics is "the language" for engineers, and it is crucial for a student to have a variety of mathematical skills in order to be successful engineer. The analysis of a typical engineering problem has two stages (a) Modeling and mathematical formulation and (b) Solving the mathematical problem. Examples of such problems are in Appendix H. The modeling stage requires a working knowledge of many different mathematical topics. Appendix I is an example of what is needed for an Electrical Engineering class, and it includes Trigonometry, vectors and Analytic geometry, functions of many variables and multidimensional calculus, matrices and linear algebra, complex numbers, setting up differential equations with the right Initial and boundary conditions. For solving problems, the emphasis is less on exact, analytic solutions and more on (a) Qualitative behavior of solutions (b) Using graphs, tables etc for solving problems and (c) Numerical methods for solving problems.

Comments about the curriculum. The engineering students need many classes in the math department including Calculus, Vector analysis, Linear Algebra, Differential equations and Engineering mathematics. The following issues are relevant to all of these classes:

- Emphasize qualitative behavior of solutions instead of theorems/exact analytic solutions. Some of the issues that the students have trouble with are – Symbol manipulation, obtaining approximate solutions of nonlinear and differential equations, and the inability to read off qualitative behavior from an expression that has parameters.

- Incorporate problems that require the use of graphs or tables to obtain solutions.

- Introduce numerical methods for solving problems. Also, choose a standard the mathematical software (Mathematica/Matlab/Maple) and use it for all the classes.

- It is important for the students to understand that the same differential equations come up in many different contexts, and often with different names. Given a problem, the students should be able to recognize the equation and properly formulate the appropriate initial and boundary conditions.

- Using examples from everyday experience, e.g., pouring coke out of a can, to train students to go through the entire process from modeling to numerical solution.

Other issues about teaching. These are some of the issues that came out of discussions with the Engineering faculty.

- Entering students seem under-prepared for college-level mathematics, especially in regards to trigonometry. This is reflected in the failure rate for math 124/125. There were suggestions for increasing the cutoff score on the placement test for admission to 124.
- It was suggested that there is significant variability in the quality of instructors for math 124/125, and this results in frustration and lack of motivation on the part of the students. Because of this, some of the faculty recommend that their students take their calculus class at Pima CC.
- Others felt that students taking their calculus at Pima community college were at a disadvantage compared to their peers who took math 124/129 at UA, because the classes at Pima did not prepare them as well. These observations are largely anecdotal, and it is important to collect and analyze data from tracking students and their grades in various classes to better understand these issues.

Optical Sciences

Notes by Robert Indik on a meeting with Bruce Bayly, Arthur Lim and Robert Indik from Math and Michael Nofziger, Bill Dallas, Grover Swatzlander Richard Shoemaker from Opt. Sci. .

We discussed math 322, math 410 and math 256, but the focus of most of the discussion was math 322. They currently (according to them) send us about 50 students a semester (I think it was per semester, not per year—it is all of there optics 310 class which they take concurrently with 322, we should check if that is offered twice a year). They also send us a significant number of students for math 410—they refer all who might want to go to grad school to math 410, perhaps a bit more than half the 322 load). They are interested in either modifying the content of 322, or having a separate section with content tailored for their students. They may be willing to provide either a body and funding for the body as a TA or just funding for a TA to help teach such a course.

The current course includes Laplace transforms which they say they do not need at all, as well as conformal maps which they also feel can be omitted for their students. They would like the course to emphasize complex Fourier series and Transform (with the real series and transform mentioned as an interesting applications). They would also like to have an emphasis on complex arithmetic and algebra (complex exponentials, a bit of calculus with complex functions, but not necessarily contour integrals, just differentiation and the simplest sort of integration) It is also quite important for them to have some matrix algebra. They want the students to be comfortable manipulating matrices and vectors in equations as objects rather than as collections of entries etc. Of less importance but still desirable is the ability to do 2x2 and a bit of 3x3 eigenvalue and eigenvector calculation. They like the current separable PDE component, though they would like the emphasis to be on wave equations. They want the students to be comfortable with Gaussians and sech functions. They would also like for the students to see Bessel functions and Airy functions (!) and Gauss Hermite polynomials. Delta functions and Green's functions were also mentioned, though I think they realized that might be pushing it. I mentioned issues with room scheduling for larger classes, and they considered whether some classes newly available in their new building might be made available.

There was also discussion of trying to coordinate the syllabi from their 310 course with the 322 course their students take.

Arthur discussed adding linear algebra to 256 and removing the phase plane analysis etc. He described his experience at Minnesota with a course he taught combining linear algebra and differential equations. We asked if the addition of some matrix algebra to 322 would reduce the demand for 410, they said probably not.

We mentioned to them the tightness of resources for teaching classes we have and the issues of room scheduling. We indicated we need to see what ECE needs to figure out whether the whole course might be changed. Potential scheduling problems for students who would have only one section to sign up for rather than the current 3-4 were discussed,. It seems plausible that since all would be at about the same stage in the Opt-Sci training, that the scheduling might not be a problem.

Architecture, BPA, and SBS

David Glickenstein, Deborah Hughes Hallett, Doug Ulmer

Introduction

In this report we summarize some of the findings related to the use of mathematics in Architecture, Social and Behavioral Sciences (SBS), and Business and Public Administration (BPA) within the University of Arizona. SBS and BPA departments are increasingly using mathematics, several having recently hired faculty with a mathematical focus to their research. However in just about every field there are specialties which use little or no mathematics which are attractive to many students with little inclination toward mathematical reasoning.

Use of mathematics in the social sciences

A common theme is that of using mathematics to handle and manipulate data. A major issue in social science research is how to translate real world data (an archaeological site, an assessment of a human's ability, a language) into a form which makes it easy to both to store and to compare with other experimental or theoretical data. In some fields, such as Archaeology or Regional Planning, finding ways to represent data is essential because one may not go back and look at the original data later. In order to find such a way to represent data, it is important to know what mathematical constructs are well understood and can be manipulated and in which ways. Data can be analyzed by standard statistical methods (such as means, standard deviation, regression), or used in graph theory, game theory, or Markov chains, for example. Many fields use classical mathematical models like predator-prey and apply them to their own disciplines.

Most departments would be willing to work with the mathematics department to develop a catalog of the kinds of problems encountered by social scientists for integration into the mathematical curriculum as examples. Some of the faculty who teach courses with significant mathematical content are listed in the last section of the report.

Current organization of math requirements

Many departments teach their own quantitative methods class for majors, which usually consists of a lot of statistics and more specialized methods. They usually assume the students are familiar with algebra, although often some students are not comfortable with even basic algebra and must do remedial work.

Some departments either have developed or are in the process of developing BS degrees which generally require more mathematics. Geography and regional planning in particular have just developed such a degree and wish to include both more mathematics and more economics, which form the basis for the field of regional planning. They currently require calculus for the BS, not because calculus is necessary, but because they would like the students to be mathematically sophisticated. They would be interested in other possibilities if they were made available.

Expectation of the students

Most departments would like their students to be comfortable with basic algebra and graphing. Some are concerned by the fact that students are not fluent with the use of percentages, and would like to see students learn statistics. In order to reach this goal, departments may require students to not only take a course covering the desired mathematics, but also a mathematics course which has the desired mathematics as a prerequisite. For instance, one semester of calculus may be required when only familiarity with college algebra is really thought to be necessary. The philosophy is that in order to get a flexible and robust knowledge set, students should take a course which uses the required skills, not just a course whose specific aim is to teach the skills. In the example, if students can really work on some calculus problems, they will have to use algebra along the way. Part of the philosophy is that if the required skills are not the culmination of the student's mathematics education, then the required skills 1) do not seem as hard and 2) must be learned more carefully and not just forgotten after the class ends. These considerations may indicate that some SBS departments would be equally or even better served by careful conceptual work on fewer topics than by an extensive exposure to many topics, since it would still allow students to hone their skills from previous math courses. It is also raises the important point that some departments may require only one semester of a year long mathematics course (such as calculus) since the content itself is not necessarily relevant.

Major mathematical teaching issues raised

Finally, we list some of the major issues brought up by those interviewed.

- **Many faculty members** (e.g. Geography, Linguistics) **were not concerned with the time it might take the students to take additional mathematics courses, especially if it were for a BS, but others** (e.g. Architecture) **encourage their students to finish their mathematics requirements as quickly as possible**, sometimes taking two math courses in one semester.

- **Many faculty members thought that a stronger mathematical background for their students would free up a lot of time in their classes** for teaching the subjects of their courses since they currently have to spend a lot of time making the students more comfortable with the mathematical background.

- **It seems that many of the faculty in the social sciences** (e.g. Psychology) **did not see a need for specialized classes or sections of mathematics specifically designed for their students.** Some felt that those students who advance to calculus, for instance, would benefit from taking classes with engineers and physical science majors.

- **Journalism, on the other hand, is very enthusiastic about a course designed for their major** (about 600 students) and is willing to collaborate in its design.

- **Many majors fields teach their own statistics class** (e.g. Psychology, Sociology), **which is often a gateway to the major. There were mixed feelings as to whether a combined class would be of benefit or not** with strong opinions both ways. It is also a question of whether such a class would be appropriately taught in a mathematics department or not. It should be noted that the mathematics department also offers a full range of statistics courses.

- **Collaboration with BPA has already been extensive**. The design and implementation of Math 115 (Business Mathematics) reflected the change in the needs of business students, and is the result of a substantial and sustained collaboration between Chris Lamoureux (Finance) and Richard Thompson (mathematics). The course is now required for all BPA students.

- Almost overwhelmingly, **departments in Social and Behavioral Sciences use the statistical tool SPSS**. This is a menu-driven statistics package that is quickly replacing all others both because it is powerful and because it is easy to use. Some fields use other specialized computational tools such as GIS (for spatial modelling).

- An interesting idea for a class which would integrate applications to social sciences and the mathematics involved (such as statistics) would be to have a course which is taught perhaps by a mathematics professor but with discipline specific laboratory sections or lectures which are taught by faculty or graduate students in social science disciplines. The idea is that the laboratories would be more project based and the mathematics would be more theory based. An interaction between faculty in the different disciplines might help students relate mathematics taught in the mathematics classroom with mathematics used in other disciplines. This would certainly need some sort of infrastructure funding.

Practical considerations

We finally list some practical considerations which were brought up in regard to restructuring the math curriculum.

- **Our collaboration with BPA needs attention**. During the last couple of semesters, BPA has not been satisfied with the teaching in Math 115. Having been given significant additional resources to do this course (laptops, training and administrative help for instructors from an academic professional, special UTAs, sessions organized by BPA on group work, a competition with judges from local businesses), our department now needs to think about how to attract instructors who would particularly like to teach this course.

- Many of the departments we consulted have a large number of majors (300-1500 students) and may have a number of staff devoted to student placement and advising. It was brought to our attention that academic advisors would not know where to send students (both undergraduate and graduate) who would like to take specialized mathematics for their work. For instance, some students in psychology or linguistics may wish to take a course on Fourier analysis or students in anthropology or geography may find a course in topology relevant. **It would be beneficial to have a clear path for a student to seek advice about which courses would be relevant for subjects they would like to learn**.

- **Some departments**, such as Journalism, **would need release time to work with Math on any projects**. However, there is interest both at UA and nationwide in forming collaboration. The Mathematical Association of America (MAA) would like UA Math and Journalism to jointly hold a national workshop on what mathematics journalism students should learn.
- It was brought up that **an interdisciplinary course was very successful in cognitive science**, which received funding from an outside source to allow several professors to get course credit for teaching the same course at the same time. Another suggestion was to tie funding to graduate student support.

Conclusion

We conclude with a summary of some of the important points made in the report:

- Mathematics is important in the social sciences as a way to model real phenomena with mathematical structures (such as numbers, percentages, matrices, graphs, etc.) which are easily manipulable.
- Regression is one of the models used in all fields, and familiarity with lines, linear functions, and graphs is essential.
- Most undergraduates will only use basic mathematics, but it is important for the students to not only be exposed to these concepts but to be comfortable with them and able to apply them to multiple situations. To accomplish this, many students are encouraged or required to take mathematics at a higher level than they are expected to use (for instance, take calculus though they may not use it).
- There are some students who may wish to take specialized mathematics courses, and it would be helpful to have an appropriate infrastructure for directing these students to appropriate courses.
- Courses designed collaboratively can be very productive. Math 115 proves that the result can benefit students. As a result, the course was selected as national model.

Faculty

Some of the faculty who contributed to this report were: Richard Bootzin (Psychology), Mark Chaves (Sociology), H. Iris Chyi (Journalism and Communications), Elizabeth Glisky (Psychology), Michael Hammond (Linguistics), John Paul Jones (Geography and Regional Planning), Alfred Kaszniak (Psychology), Susan Knight (Journalism), Chris Lamoureux (Finance), Matthias Mehl (Psychology), Susan Moody (Architecture), Lynn Nadel (Psychology), John Olsen (Anthropology), Jacqueline Sharkey (Journalism), James Shockey (Sociology and Associate Dean for Instruction of SBS).

Some social science faculty who regularly teach quantitative courses or use a lot of mathematics in their respective fields are: Ronald Breiger (Sociology), Andrew Carnie (Linguistics), Steven Kuhn (Anthropology), Ying Lin (Linguistics), Miller McPherson (Sociology), Charles Ragin (Sociology), David Sbarra (Psychology).

Appendices

Appendix A

Mathematics Courses of New Freshmen. Received June 10, 2005 from the office of Richard Kroc, Assistant Vice President of Enrollment Research and Operations, University of Arizona.

The University of Arizona
Math Courses of New Freshmen

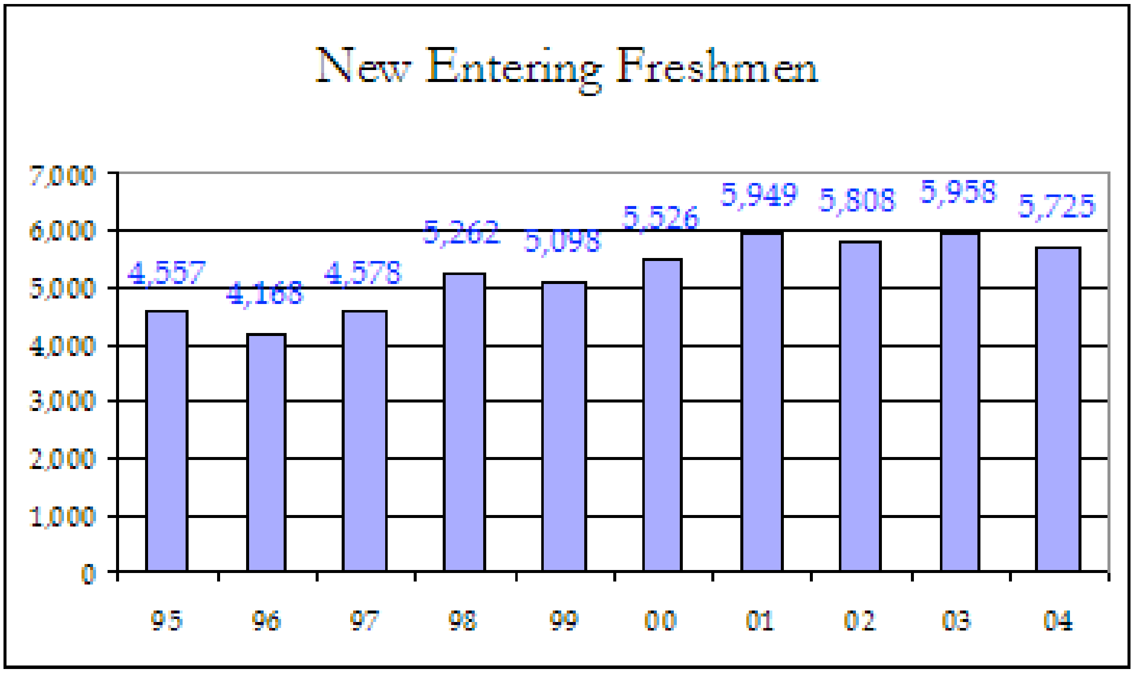
Overall Count of Math Courses Taken by New Freshmen

COURSE_ID	1998Fall	1999Spr	1999Fall	2000Spr	2000Fall	2001Spr	2001Fall	2002Spr	2002Fall	2003Spr	2003Fall	2004Spr	2004Fall	2005Spr
MATH 105	0	0	86	3	123	2	97	2	0	3	111	2	270	2
MATH 109	0	0	0	0	0	0	0	0	0	0	0	0	70	0
MATH 110	0	0	1449	42	1828	25	1997	36	1783	14	1917	36	1650	17
MATH 111	0	0	246	11	254	8	239	10	337	9	310	11	310	3
MATH 112	0	0	0	0	0	0	0	0	319	0	124	0	438	0
MATH 113	0	0	245	5	68	2	56	0	18	0	72	2	99	1
MATH 114	0	0	99	5	9	0	12	0	0	0	0	0	0	0
MATH 115A	0	0	0	0	8	4	2	1	4	1	3	1	15	0
MATH 115B	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MATH 118	151	6	0	0	0	0	0	0	0	0	0	0	0	0
MATH 119	129	5	0	0	0	0	0	0	0	0	0	0	0	0
MATH 120R	152	8	221	5	315	5	308	4	291	1	301	0	273	7
MATH 120S	0	0	0	0	22	0	3	0	8	0	17	0	0	0
MATH 121	1471	18	0	0	0	0	0	0	0	0	0	0	0	0
MATH 122	186	4	0	0	0	0	0	0	0	0	0	0	0	0
MATH 123	318	9	0	0	0	0	0	0	0	0	0	0	0	0
MATH 124	647	6	601	20	549	17	579	10	710	9	758	10	798	12
MATH 125	0	0	202	5	224	4	213	1	249	4	258	1	401	1
MATH 125A	238	2	0	0	0	0	0	0	0	0	0	0	0	0
MATH 125B	147	2	0	0	0	0	0	0	0	0	0	0	0	0
MATH 128A	0	0	29	1	0	0	0	0	0	0	0	0	0	0
MATH 129	0	0	144	14	192	5	189	1	256	5	283	2	257	1
MATH 160	6	0	14	2	11	0	10	0	15	0	13	0	8	0
MATH 195B	0	0	1	0	7	0	2	0	1	0	0	0	0	0
MATH 196A	0	0	0	0	0	0	0	0	0	0	7	0	6	0
MATH 197A	0	0	3	1	5	1	10	0	15	0	3	0	3	0
MATH 199	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MATH215	5	1	7	0	6	0	3	0	11	0	11	0	9	0
MATH223	59	2	72	1	77	1	87	2	102	3	92	0	119	0
MATH243	4	1	9	0	7	0	7	1	5	1	1	1	0	0
MATH250A	55	0	33	0	41	0	62	0	41	0	38	0	36	0
MATH254	3	0	3	0	9	2	7	1	6	0	7	0	10	0
MATH263	2	0	8	0	9	0	19	1	35	0	7	0	12	1
MATH299	0	0	0	0	0	0	1	0	0	0	0	0	0	0
MATH299H	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MATH301	0	0	2	0	0	0	2	0	0	0	0	0	0	0
MATH302A	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MATH322	1	0	0	0	0	0	0	0	1	0	1	0	0	0
MATH323	1	0	3	0	1	0	0	0	0	0	3	1	1	0
MATH355	1	0	1	0	0	0	0	0	1	0	0	0	0	0
MATH362	0	0	0	0	0	0	0	0	2	0	0	0	2	0
MATH380	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MATH396C	0	0	0	0	0	0	0	0	0	0	0	1	0	0
MATH401A	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MATH408	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MATH413	0	0	0	0	0	0	0	0	1	0	1	0	2	0
MATH422	0	0	0	0	0	0	1	0	1	0	0	1	2	0
MATH424	0	0	0	0	0	0	0	0	0	0	0	1	1	0
MATH461	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MATH464	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Total	3578	64	3479	115	3766	76	3906	70	4213	50	4340	70	4794	45

Enrollment Research (6/10/05)

Appendix B

Enrollment Trends for New Entering Freshmen. Retrieved on September 26th, 2005 from http://www.daps.arizona.edu/daps/scat/F04/NewFreshmen/frgraph.html



Appendix C (next page)

New Freshmen Mathematics Courses by Gender and Ethnicity. Received June 10, 2005 from the office of Richard Kroc, Assistant Vice President of Enrollment Research and Operations, University of Arizona.

The University of Arizona

New Freshmen Math Courses by Ethnicity & Age & Gender (Falls 2002, 2003, & 2004)

COURSE_ID	African Amer	Asian Amer	Hispanic	Native Amer	Non Res Alien	Unk / Other	White	Total	African American	Asian Amer	Hispanic	Native Amer	Non Res Alien	Unk / Other	White	Total	Ave. Age	F	M	F	M
MATH105	8	12	56	5	2	24	274	381	2.1%	3.1%	14.7%	1.3%	0.5%	6.3%	71.9%	100.0%	18.6	247	134	64.8%	35.2%
MATH109	0	1	9	3	0	2	55	70	0.0%	1.4%	12.9%	4.3%	0.0%	2.9%	78.6%	100.0%	18.6	25	45	35.7%	64.3%
MATH110	156	242	756	105	54	309	3728	5350	2.9%	4.5%	14.1%	2.0%	1.0%	5.8%	69.7%	100.0%	18.6	2919	2431	54.6%	45.4%
MATH111	42	62	206	33	20	53	541	957	4.4%	6.5%	21.5%	3.4%	2.1%	5.5%	56.5%	100.0%	18.6	415	542	43.4%	56.6%
MATH112	12	58	106	6	6	59	634	881	1.4%	6.6%	12.0%	0.7%	0.7%	6.7%	72.0%	100.0%	18.5	462	419	52.4%	47.6%
MATH113	5	37	22	4	2	10	109	189	2.6%	19.6%	11.6%	2.1%	1.1%	5.3%	57.7%	100.0%	18.6	124	65	65.6%	34.4%
MATH115A	1	1	5	0	0	0	15	22	4.5%	4.5%	22.7%	0.0%	0.0%	0.0%	68.2%	100.0%	18.7	16	6	72.7%	27.3%
MATH120R	30	48	166	26	6	49	540	865	3.5%	5.5%	19.2%	3.0%	0.7%	5.7%	62.4%	100.0%	18.7	427	438	49.4%	50.6%
MATH120S	4	0	5	0	0	1	15	25	16.0%	0.0%	20.0%	0.0%	0.0%	4.0%	60.0%	100.0%	18.6	7	18	28.0%	72.0%
MATH124	50	212	271	30	36	133	1534	2266	2.2%	9.4%	12.0%	1.3%	1.6%	5.9%	67.7%	100.0%	18.5	1004	1262	44.3%	55.7%
MATH125	11	110	79	11	44	53	600	908	1.2%	12.1%	8.7%	1.2%	4.8%	5.8%	66.1%	100.0%	18.5	344	564	37.9%	62.1%
MATH129	10	106	71	4	10	56	539	796	1.3%	13.3%	8.9%	0.5%	1.3%	7.0%	67.7%	100.0%	18.5	316	480	39.7%	60.3%
MATH160	1	3	2	1	1	1	27	36	2.8%	8.3%	5.6%	2.8%	2.8%	2.8%	75.0%	100.0%	18.6	26	10	72.2%	27.8%
MATH195B	0	0	0	0	0	0	1	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	19.3	0	1	0.0%	100.0%
MATH196A	0	3	3	0	0	1	6	13	0.0%	23.1%	23.1%	0.0%	0.0%	7.7%	46.2%	100.0%	18.4	12	1	92.3%	7.7%
MATH197A	0	0	4	0	0	0	17	21	0.0%	0.0%	19.0%	0.0%	0.0%	0.0%	81.0%	100.0%	18.5	15	6	71.4%	28.6%
MATH215	0	4	2	0	2	3	20	31	0.0%	12.9%	6.5%	0.0%	6.5%	9.7%	64.5%	100.0%	18.6	14	17	45.2%	54.8%
MATH223	2	39	17	0	1	27	227	313	0.6%	12.5%	5.4%	0.0%	0.3%	8.6%	72.5%	100.0%	18.5	89	224	28.4%	71.6%
MATH243	0	0	0	0	0	2	4	6	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	66.7%	100.0%	18.5	1	5	16.7%	83.3%
MATH250A	2	9	6	0	0	8	90	115	1.7%	7.8%	5.2%	0.0%	0.0%	7.0%	78.3%	100.0%	18.5	35	80	30.4%	69.6%
MATH254	0	5	1	0	0	1	16	23	0.0%	21.7%	4.3%	0.0%	0.0%	4.3%	69.6%	100.0%	18.4	5	18	21.7%	78.3%
MATH263	0	7	5	2	1	3	36	54	0.0%	13.0%	9.3%	3.7%	1.9%	5.6%	66.7%	100.0%	18.6	41	13	75.9%	24.1%
MATH302A	0	0	0	0	0	0	1	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	18.2	1	0	100.0%	0.0%
MATH322	0	0	0	0	0	0	2	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	18.5	1	1	50.0%	50.0%
MATH323	0	1	0	0	0	0	3	4	0.0%	25.0%	0.0%	0.0%	0.0%	0.0%	75.0%	100.0%	18.4	2	2	50.0%	50.0%
MATH355	0	1	0	0	0	0	0	1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	18.6	1	0	100.0%	0.0%
MATH362	0	0	0	0	0	1	3	4	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	75.0%	100.0%	18.6	1	3	25.0%	75.0%
MATH401A	0	0	0	0	0	0	1	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	20.0	0	1	0.0%	100.0%
MATH408	0	0	0	0	0	0	1	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	18.1	1	0	100.0%	0.0%
MATH413	0	0	0	0	0	0	4	4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	18.5	1	3	25.0%	75.0%
MATH422	0	0	0	0	0	1	2	3	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	66.7%	100.0%	18.3	0	3	0.0%	100.0%
MATH424	0	0	0	0	0	0	1	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	18.8	0	1	0.0%	100.0%
MATH461	0	0	1	0	0	0	0	1	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	18.1	0	1	0.0%	100.0%
MATH464	0	0	1	0	0	0	0	1	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	18.7	0	1	0.0%	100.0%

Enrollment Research (6/10/05)

Appendix D

Placement of Incoming Freshmen into Mathematics Courses Based on Mathematics Readiness Test A and Test B (MRTs). Received May 6, 2005 from Donna Krawczyk, former Math Readiness Test Coordinator, University of Arizona

FRESHMEN PLACEMENT BASED ONLY ON MRT (not including August)

Year	Pima 92	Pima 122	105-111	120R	113, 115A	124	125	None	Total
1999	13.1	21.9	28.8	0.3	4.8	15.7	12.7	2.7	3837
2000	12.0	21.8	32.9	3.4	4.7	13.4	10.2	1.5	3985
2001	12.7	21.2	32.6	2.7	4.8	13.4	10.6	2.0	4514
2003	11.7	20.9	32.7	3.7	5.5	13.8	10.8	1.0	4232
2004	8.2	20.2	29.9	4.0	6.0	16.9	13.2	1.7	4288

H.S.	Test A	Test B	Pima 92	Pima 122	105, 110	110, 111	120R	113, 115	124	125	None	
Amphi	10	23	4	7	1	5	0	4	8	3	1	33
Catalina	17	5	3	5	3	6	0	1	1	3	0	22
Catalina Foothills	9	81	4	4	1	10	1	11	23	38	0	92
CDO	18	35	2	7	4	8	0	2	16	14	0	53
Cholla	18	10	9	10	0	2	0	2	4	1	0	28
Cienega	8	10	4	3	0	2	3	2	3	0	1	18
Desert Christian	0	7	0	0	0	0	0	3	2	1	1	7
Desert View	7	14	4	6	0	3	1	1	3	2	1	21
Flowing Wells	1	56	0	2	0	11	3	9	18	11	3	57
Ironwood Ridge	21	11	5	10	1	5	0	2	4	5	0	32
Mountain View	4	9	2	3	0	3	0	3	2	0	0	13
Palo Verde	12	6	4	6	1	2	0	1	3	0	1	18
Pueblo	0	15	0	0	0	3	1	3	2	2	4	15
Rincon	3	21	0	3	0	6	1	1	8	3	2	24
Sabino	8	59	2	2	1	8	0	9	27	18	0	67
Sahuaro	9	29	1	5	0	5	0	2	15	10	0	38
Salpointe	50	50	3	23	10	26	2	10	16	9	1	100
Santa Rita	8	14	3	3	2	1	0	1	8	3	1	22
Sunnyside	7	30	2	12	0	7	0	2	7	1	6	37
Tucson High	46	27	11	19	4	16	0	2	9	12	0	73
Totals	256	512	63	130	28	129	12	71	179	136	22	770
2005	33.2	66.5	8.2	16.9	3.6	16.8	1.6	9.2	23.2	17.7	2.9	770
2004	31.7	68.3	6.1	18.8	3.9	16.6	1.1	8.7	26.1	17.1	1.8	725
2003	31.8	68.2	6.7	15.4	2.7	15.6	0.6	12.0	25.5	20.1	1.3	667
2002	35.0	65.0	9.3	16.2	1.5	18.7	0.5	9.3	20.7	20.1	3.8	745
2001	26.0	74.0	8.4	11.9	0.6	16.8	0.8	13.0	25.2	18.5	4.9	655
2000	20.2	79.8	8.0	12.2	1.0	15.1	1.3	6.5	30.5	19.5	5.9	524

Appendix E

Mathematics Preparation and Course Taking by School District. Received August 29, 2005 from the office of Richard Kroc, Assistant Vice President of Enrollment Research and Operations, University of Arizona.

Table 1: Fall 2004 Entering Freshmen: Number of Students Taking Various High School Math Courses by District

District	# entering	Alg1	Alg2	Geom	Trig	SeniorMath	ExtMath	PCalcMath	Cmath
Ajo Unified School District	1	0	1	1	0	1	0	1	0
Amphitheater Unified School District	229	111	207	217	140	87	13	93	0
Catalina Foothills Unified School District	188	124	181	184	126	52	8	30	1
Flowing Wells Unified School District	57	30	55	44	52	11	2	7	0
Marana Unified School District	99	62	97	97	54	27	3	36	1
Private	241	201	236	236	173	37	2	37	0
Sahuarita Unified School District	15	9	15	15	10	4	0	5	1
Sunnyside Unified School District	58	38	58	54	26	16	2	20	0
Tuscon Unified School District	568	363	526	557	324	134	16	224	1
Vail Unified School District	35	27	35	35	19	6	0	12	0

Table 2: Fall 2004 Entering Freshmen: Percentage of Students Taking Various High School Math Courses (sorted on PCalcMath)

District	# entering	Alg1	Alg2	Geom	Trig	SeniorMath	ExtMath	PCalcMath	Cmath
Ajo Unified School District	1	0.0%	100.0%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%
Amphitheater Unified School District	229	48.5%	90.4%	94.8%	61.1%	38.0%	5.7%	40.6%	0.0%
Tuscon Unified School District	568	63.9%	92.6%	98.1%	57.0%	23.6%	2.8%	39.4%	0.2%
Marana Unified School District	99	62.6%	98.0%	98.0%	54.5%	27.3%	3.0%	36.4%	1.0%
Sunnyside Unified School District	58	65.5%	100.0%	93.1%	44.8%	27.6%	3.4%	34.5%	0.0%
Vail Unified School District	35	77.1%	100.0%	100.0%	54.3%	17.1%	0.0%	34.3%	0.0%
Sahuarita Unified School District	15	60.0%	100.0%	100.0%	66.7%	26.7%	0.0%	33.3%	6.7%
Catalina Foothills Unified School District	188	66.0%	96.3%	97.9%	67.0%	27.7%	4.3%	16.0%	0.5%
Private	241	83.4%	97.9%	97.9%	71.8%	15.4%	0.8%	15.4%	0.0%
Flowing Wells Unified School District	57	52.6%	96.5%	77.2%	91.2%	19.3%	3.5%	12.3%	0.0%

Table 3: Fall 2004 Entering Freshmen: Number of Students Taking Various UA Math Courses

District	# entering	105	109	110	111	112	113	115A	120R	124	125	129	160
Ajo Unified School District	1	0	0	1	0	0	0	0	0	0	0	0	0
Amphitheater Unified School District	229	11	2	54	9	18	6	0	10	40	20	24	0
Catalina Foothills Unified School District	188	16	2	51	8	22	3	0	8	28	23	11	1
Flowing Wells Unified School District	57	5	0	13	0	8	2	0	4	13	3	2	0
Marana Unified School District	99	4	0	28	8	8	1	1	6	16	3	4	0
Private	241	9	3	78	12	16	4	0	11	33	17	10	0
Sahuarita Unified School District	15	1	0	3	1	1	0	0	3	2	1	0	0
Sunnyside Unified School District	58	1	2	16	4	4	0	1	0	5	3	0	0
Tuscon Unified School District	568	32	3	138	41	58	13	0	34	98	61	30	0
Vail Unified School District	35	1	0	9	2	5	0	0	2	4	0	0	0

Table 4: Fall 2004 Entering Freshmen: Number of Students Taking Various UA Math Courses (sorted on MATH124)

District	# entering	105	109	110	111	112	113	115A	120R	124	125	129	160
Flowing Wells Unified School District	57	9%	0%	23%	0%	14%	4%	0%	7%	23%	5%	4%	0%
Amphitheater Unified School District	229	5%	1%	24%	4%	8%	3%	0%	4%	17%	9%	10%	0%
Tuscon Unified School District	568	6%	1%	24%	7%	10%	2%	0%	6%	17%	11%	5%	0%
Marana Unified School District	99	4%	0%	28%	8%	8%	1%	1%	6%	16%	3%	4%	0%
Catalina Foothills Unified School District	188	9%	1%	27%	4%	12%	2%	0%	4%	15%	12%	6%	1%
Private	241	4%	1%	32%	5%	7%	2%	0%	5%	14%	7%	4%	0%
Sahuarita Unified School District	15	7%	0%	20%	7%	7%	0%	0%	20%	13%	7%	0%	0%
Sunnyside Unified School District	58	2%	3%	28%	7%	7%	0%	2%	0%	9%	5%	0%	0%
Ajo Unified School District	1	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Enrollment Research 8/29/05

Appendix F: Contact List

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Appendix G

Molecular and Cellular Biology faculty members were asked to answer the following questions, and to add any comments they might find useful.

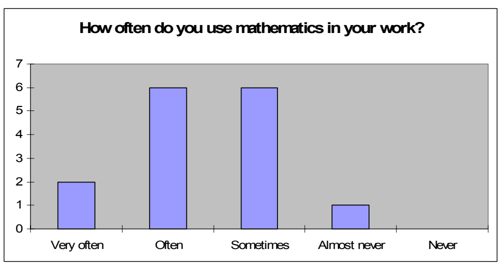
1. How often do you use mathematics in your work?

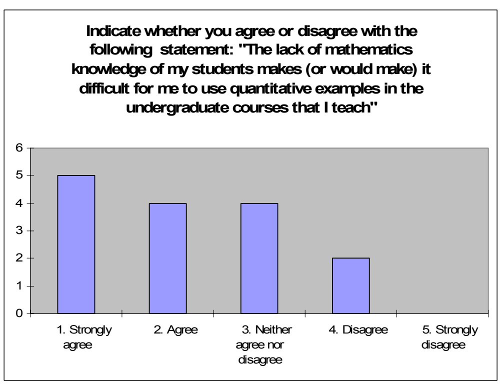
2. Indicate whether you agree or disagree with the following statement: “The use of mathematics in my field has increased dramatically over the last few years”.

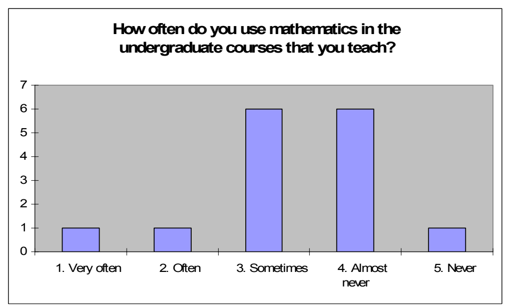
3. How often do you use mathematics in the undergraduate courses that you teach?

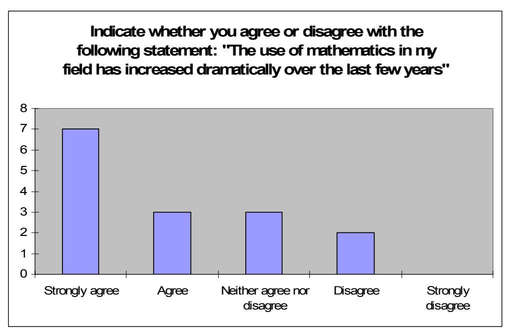
4. Indicate whether you agree or disagree with the following statement: “The lack of mathematics knowledge of my students makes (or would make) it difficult for me to use quantitative examples in the undergraduate courses that I teach”.

Answers are presented below in the form of histograms; 15 out of 17 MCB faculty members participated in the survey.









Note that Mathematics is used more in MCB faculty members’ research than it is in their teaching. The use of Mathematics in Biology has dramatically increased in the last few years, but this fact is not reflected in the teaching of undergraduate Biology, primarily because of the students’ lack of mathematical knowledge.

Below are a few selected comments from MCB faculty members:

- “We need to get our students over their fear!”

- “Modern biology training should include a thorough grounding in statistics and probability, mathematics, data and information management, and computer science/programming skills.”
- “Students are resistant to utilizing even simple algebra or use logarithms, and many are unable to draw graphs.”
- “It’s not so much the lack of mathematics, but more a fear of mathematics that is the impediment.”
- “A stronger and productive interface between MCB and mathematics is necessary.”
- “It is therefore imperative, I think, to establish collaborations with mathematicians, and maybe more importantly, to develop a PhD track which incorporates both, in depth.”
- The use of Mathematics in research and training is “very important and becoming more important”.
- “I think it is an increasingly important connection.”

Appendix I and Appendix H are provided separately