Mathematics Departments: Preparing students for the future or for the past?

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Plan of this presentation

My work with minority students and how it prepared me to work with all students.

Recruiting math majors

More mathematics makes the students more competitive

Structuring a program of study to meet the needs of students

Are mathematics departments supporting the goals of NSF?

A self-study suggestion for mathematics departments.
Work to increase minority participation

I started in the late 1980s to increase minority participation in mathematics
Minority Calculus Advising program
Weeklong Calculus Preparation Workshop
Aggressive Advising
If a student walks into my office taking calculus and does not have a major declared then...
<table>
<thead>
<tr>
<th>TIME</th>
<th>NAME</th>
<th>CLASS</th>
<th>MISC</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00-10:20</td>
<td>Alicia</td>
<td>124</td>
<td>PREN</td>
<td>Hispanic. Fr, ENGR 102 and chem</td>
</tr>
<tr>
<td>10:20-10:40</td>
<td>Emily</td>
<td>223</td>
<td>PSYC</td>
<td>Hispanic. Fr, chem 103a</td>
</tr>
<tr>
<td>10:40-11:00</td>
<td>Ryan</td>
<td>223H</td>
<td>PRPH</td>
<td>White. Fr chem. 103a, Engr 102</td>
</tr>
<tr>
<td>11:00-11:20</td>
<td>Oscar</td>
<td>223</td>
<td>NMS</td>
<td>Hispanic. So, 125 D, has done poorly. <strong>Had a long talk</strong></td>
</tr>
<tr>
<td>11:20-11:40</td>
<td>Jorge</td>
<td>223</td>
<td>MATH</td>
<td>Hispanic. Senior, Coming in from ---. If he does well, recommend RUSIS</td>
</tr>
<tr>
<td>11:40-12:00</td>
<td>Brian</td>
<td>124</td>
<td>PRCS</td>
<td>Black. Fr Mentioned adding math as a major</td>
</tr>
<tr>
<td>1:20-1:40</td>
<td>Adam</td>
<td>223</td>
<td>CVE</td>
<td>Fr. Blue Chip Program starts Sunday,</td>
</tr>
<tr>
<td>1:40-2:00</td>
<td>Claudia</td>
<td>223</td>
<td>AEE</td>
<td>Hispanic. Jr. 124 C, 129, D then C. taking physics 141</td>
</tr>
<tr>
<td>2:00-2:20</td>
<td>Sabino</td>
<td>124</td>
<td>MEE</td>
<td>Hispanic. Jr; 124, 129, 223, 254 all Cs. Why taking 124 over again. Math major?</td>
</tr>
<tr>
<td>2:00-2:20</td>
<td>Robert</td>
<td>250A</td>
<td>ELE</td>
<td>Hispanic. Fr; Eng and chem., H</td>
</tr>
<tr>
<td>2:20-2:40</td>
<td>Briana</td>
<td>223</td>
<td>BMB</td>
<td>American Indian/Alaskan Native. So. Her mom allowed her to take off work today to meet w/you. Eng and chem. H</td>
</tr>
<tr>
<td>2:40-3:00</td>
<td>Ezekiel</td>
<td>223</td>
<td>CHEM</td>
<td>Black. Jr. Must be transfer student</td>
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</table>
Associate Head position

I accepted this position in an effort to institutionalize my concern for minority education.

My efforts have resulted in an increase in the number of mathematics majors.

The data.
## History of the program

<table>
<thead>
<tr>
<th>Year</th>
<th># of Math majors</th>
<th>% of minority math majors</th>
<th># of math minors</th>
<th># of grads</th>
<th>% of minority grads</th>
<th>% of grads with double major or two degrees</th>
<th>% pursing post-grad</th>
<th>% of grads pursuing grad school in math/stat</th>
<th>% of grads pursuing middle and high school teaching</th>
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</thead>
<tbody>
<tr>
<td>2000-01</td>
<td>295</td>
<td>~15%</td>
<td>199</td>
<td>46</td>
<td>13%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001-02</td>
<td>327</td>
<td>~15%</td>
<td>355</td>
<td>52</td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002-03</td>
<td>323</td>
<td>~15%</td>
<td>390</td>
<td>59</td>
<td>8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003-04</td>
<td><strong>307</strong></td>
<td>~15%</td>
<td><strong>447</strong></td>
<td><strong>50</strong></td>
<td><strong>6%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004-05</td>
<td>456</td>
<td>~15%</td>
<td>531</td>
<td>65</td>
<td>20%</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2005-06</td>
<td>472</td>
<td>16%</td>
<td>487</td>
<td>62</td>
<td>8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2006-07</td>
<td>505</td>
<td>19%</td>
<td>527</td>
<td>82</td>
<td>13%</td>
<td>30%</td>
<td>38%</td>
<td>12%</td>
<td>17%</td>
</tr>
<tr>
<td>2007-08</td>
<td>564</td>
<td>22%</td>
<td>572</td>
<td>79</td>
<td>14%</td>
<td>37%</td>
<td>24%</td>
<td>9%</td>
<td>15%</td>
</tr>
<tr>
<td>2008-09</td>
<td>567</td>
<td>22%</td>
<td>562</td>
<td>70</td>
<td>21%</td>
<td>40%</td>
<td>30%</td>
<td>9%</td>
<td>21%</td>
</tr>
<tr>
<td>2009-10</td>
<td>582</td>
<td>20%</td>
<td>624</td>
<td>92</td>
<td>17%</td>
<td>40%</td>
<td>33%</td>
<td>16%</td>
<td>13%</td>
</tr>
<tr>
<td>2010-11</td>
<td>638</td>
<td>21%</td>
<td>650</td>
<td>107</td>
<td>15%</td>
<td>45%</td>
<td>26%</td>
<td>8%</td>
<td>18%</td>
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<tr>
<td>2011-12</td>
<td>605</td>
<td>20%</td>
<td>697</td>
<td>109</td>
<td>17%</td>
<td>47%</td>
<td>29%</td>
<td>11%</td>
<td>12%</td>
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<tr>
<td>2012-13</td>
<td>641</td>
<td>20%</td>
<td>717</td>
<td>125</td>
<td>17%</td>
<td>41%</td>
<td>28%</td>
<td>12%</td>
<td>14%</td>
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<tr>
<td>2013-14</td>
<td>629</td>
<td>22%</td>
<td>714</td>
<td>101</td>
<td>22%</td>
<td>51%</td>
<td>27%</td>
<td>13%</td>
<td>6%</td>
</tr>
</tbody>
</table>
In 2003 I became Associate Head

• We had a 50% increase the following year.
• My strategy
• I looked at enrollments of every upper division math course
• I looked at the background of every student in that course and if they were not a math major I sent an email message suggesting the math major or minor or perhaps enrolling in a different course
• The best students at a university can be mathematics majors
• An example
Four UA Students Named Goldwater Scholars

The four UA students to be named Goldwater Scholars are (left to right) Stacy Marla Shiffler, Jennifer Sierchio, Beryl Jones and Troy J. Comi. (Photo courtesy of Leslie Johnston)

Each of the University of Arizona students nominated for the Goldwater Scholarship was selected for the award – a rarity for most institutions nationally.

Of the 278 scholarships awarded by the Barry M. Goldwater Scholarship and Excellence in Education Foundation for the 2010-2011 year, four of them were UA Honors College students.

"We typically have at least one, usually two and sometimes three students selected but in my recollection, this is the first time we've had all four selected," said Karna Walter, director of nationally competitive scholarships at the UA's Honors College.

Troy Comi: Comi, a senior, majors in chemistry, biochemistry, computer science, mathematics and molecular and cellular biology.

Beryl M. Jones: A triple major studying biochemistry and molecular biophysics, ecology and evolutionary biology and also molecular and cellular biology, Jones also has minors in chemistry and mathematics.

Stacy Marla Shiffler: A physics and applied mathematics major.

Jennifer Sierchio: A triple major in astronomy, physics and mathematics.
William Velez wrote:

Dear Stacy:

I was going over enrollments for math 223 and I came across your name. I see that you did very well in this course and I congratulate you for your efforts. It appears that you are interested in physics. Have you ever thought of adding mathematics as another major? If you have any thought of pursuing an advanced degree in physics you will find that the undergraduate mathematics will be of tremendous assistance in that endeavor. After 254 you only need to take 7 more mathematics courses to complete the math major requirements. Here is a sample schedule that would allow you to complete the math major requirements in four years.

S08: 254  
F08: 215  
S09: 323, 422  
F09: 454  
S10: 456  
F10: 413  
S11: 485  

If you would like to talk about these possibilities, send me a message and we can arrange to meet in my office. My office, Math 219, is part of the Math Center.

Best. WYV
April 08, Message 2
Following my suggested schedule

• Quoting William Velez <velez@math.arizona.edu>:

Dear Stacy:

I see that you are enrolled in math 215 and 422 for the fall. I have revised the schedule to show you what would remain to have you complete the math major requirements.

F09: 215, 422
S10: 485, 323
F10: 413, 454
S11: 456

Would you like to stop by and discuss the benefits of adding math as another major?

WYV
April 08, Message 2
Following my suggested schedule
Again, no reply

• Quoting William Velez &lt;velez@math.arizona.edu&gt;:

Dear Stacy:

I see that you are enrolled in math 215 and 422 for the fall. I have revised the schedule to show you what would remain to have you complete the math major requirements.

F09: 215, 422
S10: 485, 323
F10: 413, 454
S11: 456

Would you like to stop by and discuss the benefits of adding math as another major>

WYV
October 08, Finally, a reply

Dear Dr. Velez,

Thank you for taking the time to contact me and send me a tentative schedule. I am considering declaring a math major, but I am going to wait and see how I do next semester with 215 and 422 and then make a decision. I want to be sure that I really enjoy math before I make any commitments. If I have any questions next semester I will certainly contact you.

Thanks again for spending your time on this; it really is encouraging and helpful.

Stacy Shiffler
Great, I look forward to hearing from you. Since you are interested in mathematics, I would like to talk to you, even if you are not ready to declare the math major. The schedule that I sent you is but one of the options that are available for math majors. I would like to get a better idea as to your academic plans so that I can provide you with better advice.

I am currently in Chicago and I won't be home until Wednesday. Could we talk next week? What times are you available on Thursday or Friday of next week?

WYV
I never suggest that students change majors

Every conversation that I have with students begins with:
What are your goals?
I then have to think about how taking more mathematics can help the student reach those goals.
Since we have so many math majors, it is a common occurrence that the outstanding graduating senior in other majors is also a mathematics major.
The mathematics major at the UA has seven options, designed to meet the goals of students.
It's lovely to hear from you! I am doing quite well over here in NJ. I am getting close to being halfway through the fourth year of my PhD, and I am studying physical oceanography. At the end of this month I will be going to tea on the Southern Ocean for two months, and I get to go to Antarctica!

As far as my math preparation is concerned, I am thankful everyday that I studied math in undergrad. It was particularly helpful during the first two years of my program here when I was taking courses. It's also a huge confidence boost to have a math degree under my belt. When I go to tackle problems I don't feel afraid because I know I can either a) do the math already, or b) know enough math to be able to figure out new things and teach myself. Plus I just like it :)

Studying math also opened up a lot of doors for me. At the end of undergrad, when I wasn't sure what I wanted to study in graduate school I figured the math background would give me a great jumping off point for anything in the sciences, and that was definitely the case. There are many students in my program who don't have a climate science background (including me), but instead have "only" math (and in some cases not even applied math) backgrounds and they do just fine. Not only that, it's extra great to be able to do quantitative analysis because the financial market is always looking for people who can do that sort of thing. Right now I actually have a hedge fund from London talking to me because they know I have a math background and am getting a PhD in physical oceanography. They don't care that I have no financial background.
What is a mathematics major

Every mathematics major takes the same core:
3 semester of calculus, differential equations, linear algebra, introduction to proofs.
After this core, students are required to take either 5 or 6 more upper division mathematics courses.
Options

1. Comprehensive
2. Computer Science
3. Economics/Business
4. Probability/Statistics
5. General/Applied
6. Life Sciences
7. Teaching
Comprehensive Option

Year-long course in abstract algebra
Year-long course in advanced calculus
Semester course in linear algebra
Semester course in complex variables

Students who are considering graduate school in mathematics choose this option
However, it is possible to graduate as a mathematics without taking any of these courses.
The traditional program of study in mathematics

Is it designed to prepare students for the workforce or to prepare students to pursue graduate studies in a variety of areas?

My impression is that the undergraduate curriculum, in general, is designed to allow mathematics faculty to teach the courses that they were trained in.

Tradition

Do our graduate programs even prepare students for graduate study in the mathematical sciences?
Preparing students for graduate study in the mathematical sciences

Mathematics
Applied Mathematics-Advanced calculus, linear algebra, differential equations, numerical analysis
Statistics-Advanced calculus, linear algebra, probability theory, statistics
Biostatistics-Three semesters of calculus and linear algebra

By having a traditional program of study we are discouraging American students from participating in graduate study in the mathematical sciences.
Are mathematics departments supporting the core values of NSF, the primary funding agency?

Scientific Excellence – engaging the vision and expertise of our staff with that of the scientific community to create a portfolio of awards that support transformation and innovation; Organizational Excellence – investing the resources entrusted to us optimally and efficiently, and realizing the full potential of our people in managing a capable, motivated, inclusive, and positive work environment; Learning – continually identifying opportunities for learning and professional growth inside and outside the agency, and sharing our best insights with others; Inclusiveness – seeking and embracing contributions from all sources, including underrepresented groups, regions, and institutions; Accountability for Public Benefit – operating with integrity and transparency, and maintaining the highest standards of performance in administration, business processes, management, and oversight, thereby providing the best value to the U. S. taxpayer.
Self study suggestion

I suggest that departments perform a self-study on their undergraduate and graduate program. Moreover, this departmental self-study should be part of any proposal from a faculty member to NSF. The self-study should be evaluated in view of meeting the core values of NSF and its evaluation should impact the appropriateness of funding a proposal from that departmental faculty member.
The self study

How many bachelor’s degrees were awarded in mathematics, with the data disaggregated:
  • male-female, minority, international

How many MS and PhD degrees were awarded in mathematics, with the date disaggregated:
  • male-female, minority, international

Employment history of doctoral recipients: Where did the doctoral students end up after 5-6 years?

Doctoral programs think that they are producing researchers.
An example of the data
The distribution of the total number of papers per author*

Patterns of Research in Mathematics, Notices of the AMS, January 2005

Herrold W. Grossman
Self study

Departments should understand where their graduates end up. This could inform the preparation that departments provide.