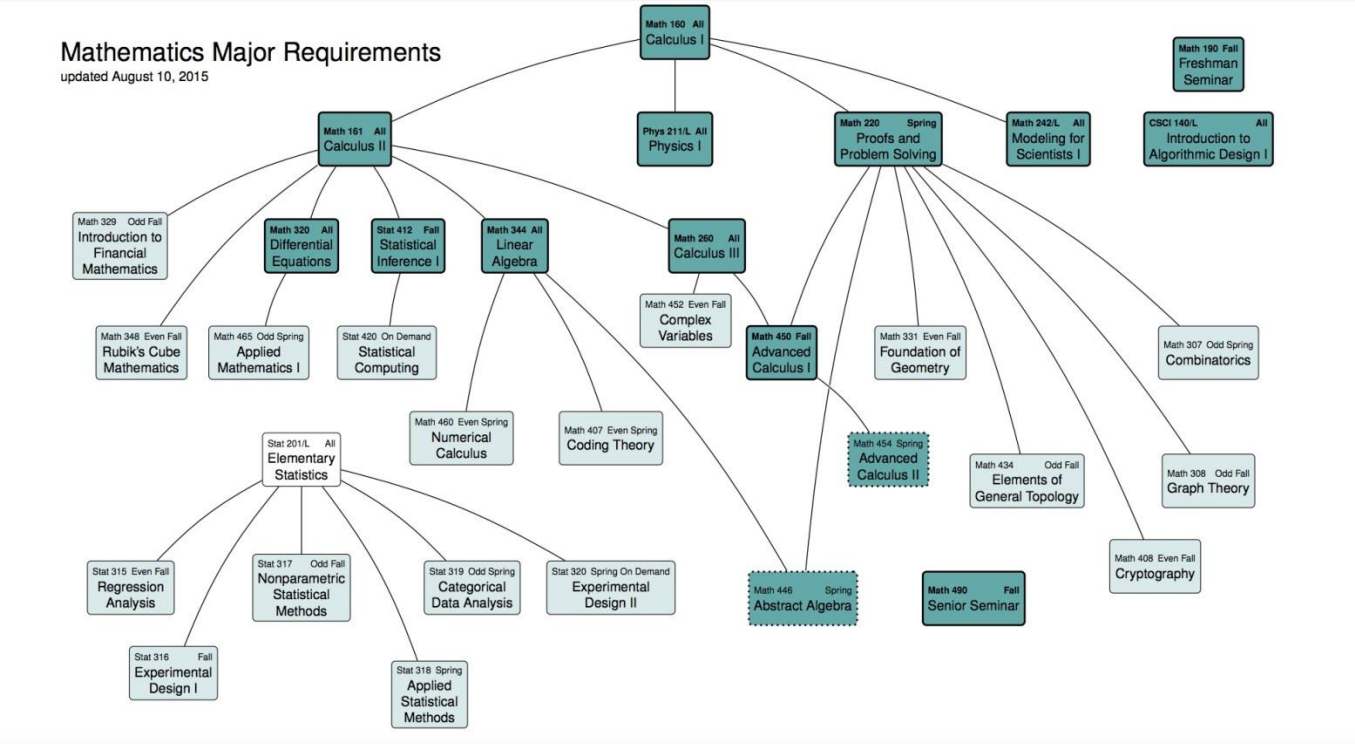
Information to Guide Curriculum Discussion FA 16

To aid our discussion on curriculum reform, the curriculum committee has compiled some information that may be of use. Several people contributed information so the style and format may be a little disparate, but diverse points of view are great! Consider perusing this document before our meeting on ***Monday, 9/12/16.***

I. Refresher on our requirements
II. List of comparable schools and their requirements
III. Highlights from UT-Austin's Mathematics Department Curriculum
IV. Suggestions from recent literature
V. Suggestions to start the conversation on improvement (i.e. brainstorming from curriculum committee members)

I. Refresher on our requirements



II. List of comparable schools and their requirements

- Arkansas State University
  - Public school with about 14,000 students on the main campus (21,000 overall)
  - Also has a combined Math/Stats department
  - Offers a B.S. in Math

CCU		**A-State**	
Other	68	Other	64
Calc 1	4	Calc 1	4
Calc 2	4	Calc 2	4
Calc 3	4	Calc 3	4
Modeling	4	Modeling	3
Proofs	3	Discrete	3
Diff Eq	3	Diff Eq	3
Lin Alg	3	Lin Alg	3
Advanced Calc	3	Advanced Calc 1	3
Algebra or Analysis	3	Advanced Calc 2	3
Seminar	3	Algebra	3
Statistical Inference	3	Prob/Stats 1	3
Two More 300+	6	Prob/Stats 2	3
Three More 400+	9	Applied Stats	3
		Applied Stats 2	3
		History of Math	3
		Geometry	3
		Applied Math	3
		PDEs	3
Total Credits	120	Total Credits	121

- UNIVERSITY OF FLORIDA
  - Calculus 2, 3 (8)
  - Differential Equations (3)
  - Sets and Logic (proofs) (3)
  - Linear Algebra (3)
  - Abstract Algebra (3)
  - Advanced Calculus 1 and 2 (6)
  - Four Electives (12)

  A total of 38 credits in Math courses. Total of 120-124 credits (major and non-major) for the math degree.

- FRANCIS MARION
  - Math Sciences Option:
    - Calc I, II, III (3+3+3=9)
    - Linear Algebra (3)
    - Multivariable Calculus (3)
    - Capstone Course (3)
    - Transition to higher level math (3)
    - 3 math electives above 199 level at least one 400 level (3+3+3=9)
    - Computer Science (3)
    - One of Abstract Algebra, Real Analysis, or Mathematical Probability (3)
    - Total of 33 credits in the math department.
  - The minimum number of semester hours required in major courses in mathematics is 33 for the Mathematical sciences option and 36 for the Teacher Licensure Option.
  - The minimum number of semester hours in all courses (major and non-major) required for the major in mathematics is 120. (121 for Teacher Licensure Option if the collateral is chosen in biological or physical sciences)

- FURMAN
  - Mathematics Major: Requires 11 courses: 2 required, 2 “choose one”, and 7 electives.
  - Two required courses are Transition to higher Mathematics and Vector Calculus.
  - Two choose one courses are : One of Linear algebra or Modern Algebra and One of Real Analysis or Complex Variables
  - 7 electives from Vectors and Matrices, Calculus II, Operations Research, Differential Equations, Scientific Computation, Mathematical Models and Applications, Probability, Mathematical Statistics, Number Theory, Modern Geometry, Combinatorics and Graph Theory, Topology, Topics in Algebra, and Topics in Analysis.
  - All the courses are 4 credits. The math major requires a total of 44 credits in the math department.

- WOFFORD COLLEGE
  - Math Major
    - Calculus I, II, III, Linear Algebra, Introduction to mathematical proof (15 credits) and 6 electives (18 credits)
    - Total of 33 credits in the Math department.
  - Applied Mathematics Major
    - Calculus I, II, III, Modeling, Linear Algebra, Differential Equations, Introduction to Math proof (21 credits) and 2 electives (6) and 3 upper level electives (9-12)
    - Total of 36-39 credits in the Math department is required.

- ELON UNIVERSITY
  - Mathematics Major (BS):
    - Calculus II, III (8), Linear Algebra (4), Proofs (4) , Abstract Algebra (4), Analysis (4), two seminars (4), two electives (8), computer science and physics courses (16).
    - A total of 40 credits in the Math department is required. (56 including the out of department requirements)
  - Applied Mathematics Major**:**
    - Calculus I, II, III (12), Linear Algebra (4), Differential Equations (4), Computer Science (4), three electives (12), capstone (2-4).
    - A total of 38-40 credits in the Math department is required

- THE CITADEL
  - Calculus I, II, III (12), Proofs (3), Applied Math (3), Linear Algebra (3), Modern Algebra (3), Introduction to Probability and Statistics (3), Introduction to Analysis (3), Math. Models (3), Senior Seminar (3), Electives (12 credits)
  - Total of 49 credit hours in the Math department.

- **University major requirements (preliminary comments)**

  Below I've compiled a list of approximate credit requirements for a small handful of universities. These are mostly southern regional universities and/or in state schools, but I've also included my alma mater since the info was pretty easy to find. I list, if there are multiple options, requirements for the mathematics major and the mathematics education track.

  - Note 1: I will count the following as "Standard" courses typical to most mathematics majors: Calc I, II, III; Differential equations, Linear, Proofs, Algebra, Advanced Calculus. Depending on whether the Calculus sequence has courses for 3 or 4 credits each, this totals to 24-27 credits.
  - Note 2: Schools vary, but most require a CS course, 1-2 stats courses, and 1-2 physics courses alongside their major. Since not all of these requirements were not present at each school, the numbers below restrict to courses specifically with a "MATH" course heading. (Sorry, stats people!)

- Note 3: If there were math ed course requirements that fell under a "MATH" course heading (e.g. math instruction with technology, student teaching, etc.), they have not been counted here. We don't currently offer upper level Math Ed electives that can be counted towards the major here, and it appears typical for these kinds of math ed electives to not be allowed to count as upper level electives towards standard math majors.
- Note 4: Where schools offered both BA and BS options, I've noted the BS requirements. Where schools offered both a pure and an applied math option, I've noted the pure math requirements since not all schools had an applied option.

Schools: course program (credit count)

- Virginia Tech: Standard + "bridge" courses (intro to linear, intro to vectors, intro to multivariable calc) + 4 electives. (27+7+12= 43 total hours)
- Virginia Tech Math Ed: Standard - Calc III + "bridge" courses + History of math, College Geo, and 1 elective (24 -3 +7 +9= 37 total hours)
- USC: Standard + 4 upper level electives (24+12 =36 total hours)
- UNC Wilmington: Standard + Seminar + 2 upper levels and 4 upper level electives (27+3+18=48 total hours)
- UNC Wilmington math ed: Standard - Differential Equations + College Geo, History of math, 2 electives (27-3+12=36 hours)
- Winthrop: Standard + Seminar, Combinatorics, a 1 credit mathematica course and 4 electives, (27+19=46 total hours)
- Winthrop math ed: Same as above, but only 3 electives instead of 4 (43 total hours)
- College of Charleston: Standard + Complex Variables, Geometry, Numerical (4 credits)+ 3 electives (27+10+9=46 total hours)
- College of Charleston math ed: Standard + Geometry, Research, Probability, Modeling, (27+13=40 total hours)
- Appalachian State: Standard + whatever electives needed to pad to 44 credits (44 total hours)
- Coastal: Standard + 242, 490, 5 electives (27 + 22 =49 total hours)

III. Highlights from UT-Austin's Mathematics Department Curriculum

(http://www.ma.utexas.edu/)

"Inquiry-Based Learning (IBL) is an approach to teaching that challenges students to think like mathematicians and to acquire their own knowledge by creating/discovering mathematics." (Ernst, 2013) *Often referred to as Moore Method or Modified Moore Method after Robert L. Moore*

- Each semester **at least** one section each of M325K Discrete, M328K Number Theory, M361K Intro to Real, M362K Probability, and M333L Structure of Modern Geometry is taught as an **IBL class**.
  - Often multiple sections of M325K (Discrete) is taught with IBL.
  - This has been done by creating a list of instructors for each course who agree that they will teach certain courses in an IBL way.
- **All Calculus classes have been "flipped,"** meaning that students watch online modules that introduce the Calculus concepts before they come to class. Then, students must take a short online quiz* after viewing each module to insure that they are watching them. In class, more time is spent having students solve problems together and having them do and present inquiry-based exploration problems.
- An upper division math course (M375D Discovery) has been developed to allow **discovery and inquiry as a capstone choice** for math majors.

- 'Signature Courses' were developed for incoming freshman in the College of Natural Sciences.
  - All freshmen in CNS must take a Signature course in one of the CNS disciplines.
  - Mark Daniels offers a full IBL course called *From Numbers to Chaos*
  - Mike Starbird offers a full IBL course called *Elements of EffectiveThinking.*

- Mike Starbird and Mark Daniels are creating a text for a Freshman Research Initiative (FRI) course that freshmen (mostly math majors) can take during their Spring semester.
  - The course will help promote and prepare students to continue on a path to doing some type undergraduate research project before they graduate.
  - These courses will also be full IBL.

- **Quest is an online learning and assessment system** that provides tools for incorporating online multimedia content and assessments in courses. Quest has an extensive question bank of over 60,000 questions in Mathematics, Biology, Chemistry, and Physics.

- **Math Major UT-Austin (BS : Pure Mathematics)**
  UT-Austin provides a variety of math degree plans ranging from a Teaching option to actuary.

  1-4. Core Curriculum.

  5. Eight semester hours of majors-level coursework in one of the following areas: astronomy, biology, chemistry, geological sciences, and physics
  6. Elements of Computers and Programming. (CS Course)
  7. Differential and Integral Calculus. AND Sequences, Series, and Multivariable Calculus.

8. Three of the following: Multivariable Calculus. Differential Equations with Linear Algebra. Linear Algebra and Matrix Theory. Probability I.
9. Discrete Mathematics. Or Introduction to Number Theory.
10. One of the following: Introduction to Algebraic Structures. Introduction to Real Analysis. Real Analysis I. Topology I. Algebraic Structures I.
11. 21 additional hours of mathematics, chosen from Mathematics 325K, 427J or 427K, 427L, 328K,329F, 333L, 339C, 339D, 339J, 339U, 339V, 339 W, 340L or 341, 343K, 343L, 344K, 346, 348, 349P,349R, 358K, 361, 361K, 362K, 362M, 365C, 365D, 365G, 367K, 367L, 368K, 372K, 373K, 373L,374G, 374M, 375D, 378K, and 379H.
12. **One course identified as taught in the inquiry based learning (IBL) format. IBL courses are identified each semester through a notation under the unique number in the Course Schedule and through a list maintained in the mathematics advising office in Robert Lee Moore Hall, room 4.101**

IV. Suggestions from recent literature

2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences

This resource contains specific recommendations for the teaching of individual courses. That is not our focus here. Instead, the focus is on what courses should be included in a major.

Content Goals for Designing a Major

1. Include concepts and methods from calculus and linear algebra
2. Learn to read, understand, analyze, and produce proofs at increasing depth as they progress through a major
3. Include concepts and methods from data analysis, computing, and mathematical modeling
4. Present key ideas and concepts from a variety of perspectives to demonstrate breadth of mathematics.
5. Experience mathematics from the perspective of another discipline
6. Present key ideas from complementary points of view: continuous and discrete; algebraic and geometric; deterministic and stochastic; exact and approximate
7. Require the study of at least one mathematical area in depth, with a sequence of upper –level courses
8. Work independently, or in a small group, on a substantial mathematical project that involves techniques and concepts beyond the content of a single course
9. Offer an orientation to careers in mathematics

Cognitive Goals for Designing a Major

1. Develop effective thinking and communications skills
2. Learn to link applications and theory
3. Learn to use technological tools
4. Develop mathematical independence and experience open-minded inquiry

Miscellaneous Comments and Recommendations

1. While developing applications of mathematics, departments should continue to offer an option for a major in mathematics that is more traditional in scope and purpose ("pure math").

2. Consider looking at the MAA Committee on Department Review's document called *Guidelines for undertaking a self-study in the mathematical science.* This provides guidelines for planning assessment and offering renewal to the program. For example, develop short term (1 or 2 year) and long term (5 year) goals along with concrete actions to achieve those

3. As the business model changes at universities, mathematics departments need to have a seat at the table when it comes to creating online courses and content.

4. Make sure we are aware of the expanding role of mathematical sciences across disciplines. Communicate this to our students and train them to satisfy such opportunities.
5. Strongly recommend that math majors take an introductory statistics course within the first two years.

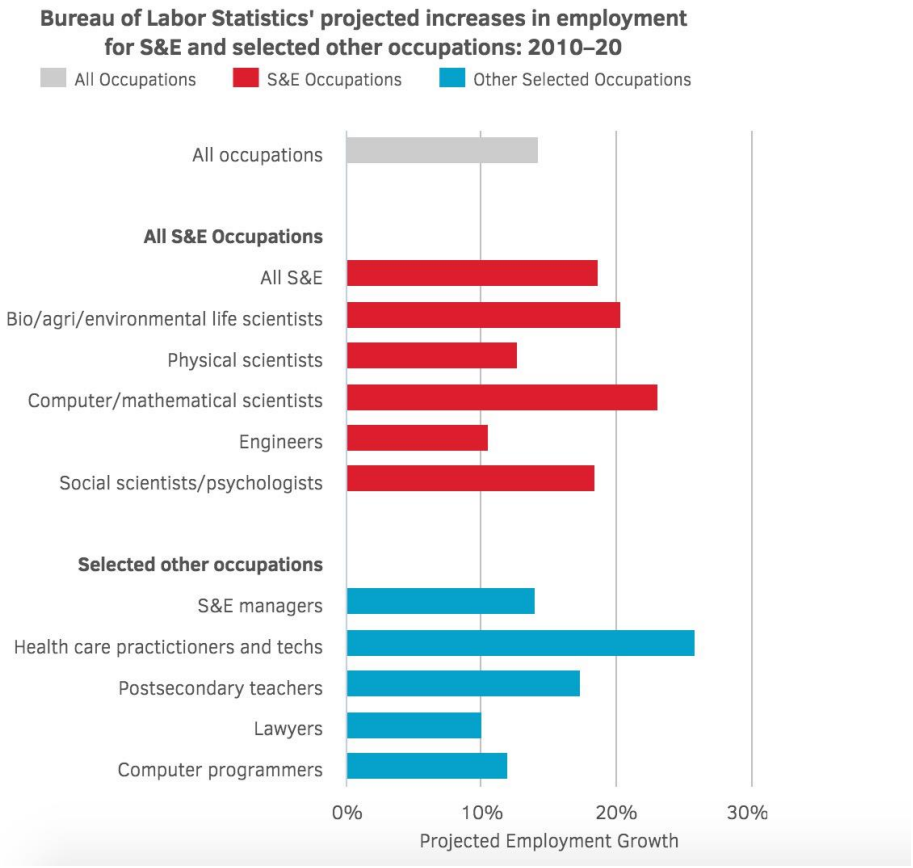
6. Nearly all doctoral programs in pure math require their students to have undergraduate courses in real analysis and abstract algebra.

7. Nearly all PSM programs (professional science masters such as biotechnology, nanotechnology, etc.) require calculus, linear algebra, and probability and statistics. Mathematical modeling is also highly desirable. In addition, a course in the area of interest such a financial math, computational mathematics, data analytics, or bioinformatics

8. …"We have opted to focus on the most important change we think undergraduate mathematics programs needs to make as we prepare 21st century mathematics majors: to provide and actively encourage all students majoring in the mathematical sciences to include at least one course in applied data analysis (not intro stat or mathematical statistics)

NSF data and projections for Science & Engineering (S&E) degrees

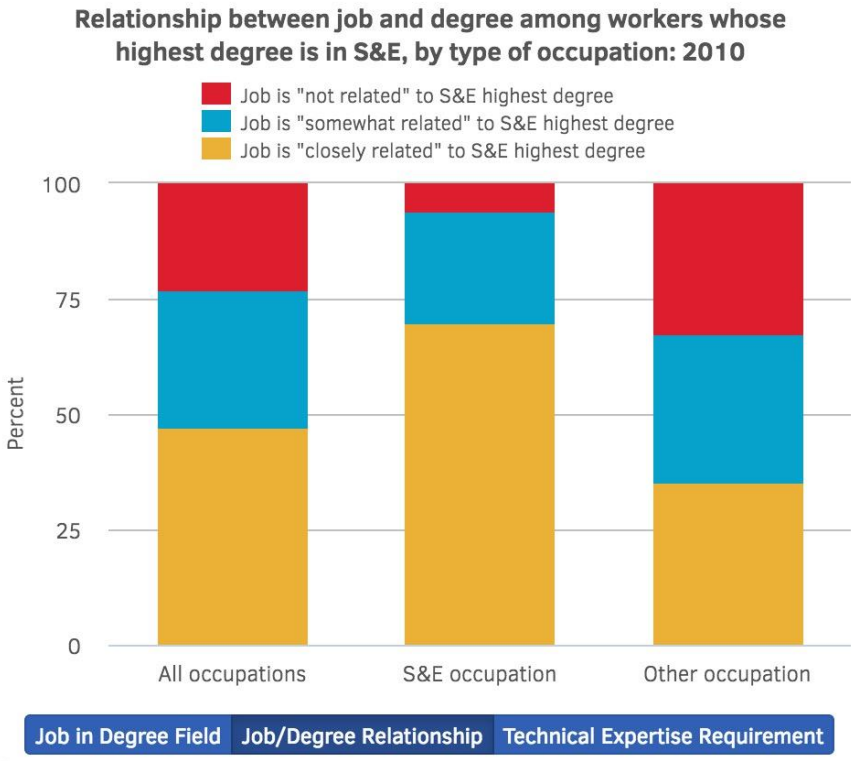
https://www.nsf.gov/nsb/sei/edTool/data/workforce-03.html



Key observations:

- "Approximately 59% of the projected increase in S&E jobs is in computer/mathematical scientist occupations. These occupations also have the largest growth rate (23.1%)."

- In addition, notice that postsecondary S&E teachers have a higher growth rate, so it might be worth investigating specific tracks of the curriculum for future teachers (I assume we need to chat with the MAT program about this). Along these lines, there is a nationwide movement to improve STEM education (https://100kin10.org/about and the very recent White House call to action https://www.whitehouse.gov/blog/2016/08/17/call-action-incorporating-active-stem-learning-strategies-k-12-and-higher-education).



Notes:
S&E = science and engineering (biological/agricultural/environmental life sciences, physical sciences, computer/mathematical sciences, mathematics/statistics, engineering, psychology, and social sciences)
Physical sciences = chemistry, physics, astronomy, and earth/ocean/atmospheric sciences.

https://www.nsf.gov/nsb/sei/edTool/data/workforce-06.html

It's also worth noting that S&E occupations are more related to S&E degrees (as compared to other fields and jobs).

V. Suggestions to start the conversation on improvement (i.e. brainstorming from current curriculum committee members)

- Considering the fact that almost all of the schools require less math requirements than us, I think it is appropriate for us to require one or two electives less for our math major

- We're not a school of the same size or ranking as A-State, but it's worth comparing the two schools. A-State has more of a traditional degree and more two-semester sequences. I'm less inclined to cut courses at this point but change the prerequisites. For example, I don't think Proofs is a necessary prerequisite of Cryptography since the equivalent Computer Science prerequisite is just Math 174: Intro to Discrete. It might be worth reevaluating the prerequisites for some of the 400-level courses.

- Another idea is that I have seen Differential Equations run as a 4-credit course. If it's possible, maybe we can cut one elective and bump up Differential Equations and another common course (Linear Algebra? Proofs? STAT412?) to being 4-credit courses. We would need to discuss if there is enough content in these courses to run as a 4-credit course.

- **Observations/comments (1)**
  There were concerns that we were credit heavy on our course requirements for mathematics. Many schools seem to vary on whether they consider non-math STEM requirements to be in-major requirements or not. Normalizing for this by only looking at subject requirements with a MATH course designation, we do appear to be on the upper end of what is considered normal for credit requirements for a "regular" mathematics major. Most programs tend to encompass the "Standard" coursework + 4-6 upper level additional classes.

  - Suggestions: We may have room to cut an in-major elective (say, a 4000 level) from our major requirements, and still have a relatively standard program. If we would like to work with the students regarding alternative paths toward majoring as encouraged by TPSE Math, another potential option is to develop a list of math-intensive upper-level interdisciplinary courses that we would allow to cross-list and count towards our upperlevel math requirement. (A possible example, Physics 310: Mathematical Methods in Physics. I'm sure there must be others from chem/phys/compsci that would work as well.) These would likely overlap with courses that have already been approved for usage as cognate courses. We could place a cap (1 or 2?) on the number of such courses that count towards the major, so we actually do ensure that students with math majors take upper level math courses. I would guess that this could potentially encourage some of our Computer Science/Physics students to double major rather than just minor, since there is already overlap with their required coursework. Further, since we are on the upper end of credit requirements for the major, allowing one or two of these substitutions would again place us as still having fairly standard program content.

- **Observations/comments (2)**
  It seems typical that whenever a Mathematics Education track is available, these programs require less MATH designated coursework than standard tracks. These are typically offset by increased coursework in mathematics education, general education, psychology, or sociology courses. Considering that many of our students are planning on going into teacher certification programs, we are making these students take a larger than normal amount of MATH designated coursework than their peers, with no real guarantee that they have any education-related course experience until they are in the MAT program. Strength in content area is correlated with better teaching, but pedagogy and classroom management are a *large* component of running a K-12 classroom—large enough that it seems strange to speak nothing of for 4+ years, and then expect students to achieve mastery of in a 14-month program.

  - Suggestions: I view this as being problematic, since it seems we are not really serving the needs of one of our larger populations of majors. I would suggest progressing through the following sequence of steps in some slightly overlapping order.

    1. The bandaid: In line with my previous suggestion of cross-listing courses, we could allow students to take education related coursework to count towards upper level "math" electives if they are planning on applying to the MAT program. (PSYC 428: School Psychology and Exceptional Children, as an example perhaps? Again, I'm sure there
    2. must be other examples from the psych/sociology/education departments that would be accessible to undergrads.)
    3. A bigger bandaid: We could develop relevant math education-related coursework to better serve students planning on going into the MAT program.
    4. The overhaul: We could make plans for developing a mathematics education major.