Mentoring, Outreach, and Teaching

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I have had experience teaching a range of undergraduate, and graduate classes including all levels of calculus, linear algebra, graph theory, abstract algebra, algebraic geometry, the history of mathematics, as well as a number of topics courses. I have also been involved in mentoring at a variety of levels, and in efforts aimed towards broadening the pipeline of talent flowing into STEM fields.

Here I briefly describe some of these activities.

Mentoring

- The **Early Career Section** is a new community project in the AMS Notices, which I have designed, in consultation with editor in chief Erica Flapan. This column provides information and career advice to graduate students, job seekers, early career academics of all types, and those who mentor them. We consider aspects of the profession, arranged in themes. In the first issue, January 2019, I introduced the series, and Rob Lazarsfeld's piece on keeping a research journal appeared. Themes for the first year included: research (February); writing (March); jobs in business, industry and government (April); time/summer/conference planning (May); the academic job market (June/July); teaching (August); mentoring (September); work/life balance (October); giving talks and preparing for the joint meetings (November); and in December, in our "best practices issue", we will look back and highlight programs and departments that are doing interesting positive things that others might be able to emulate.

  About fifty mathematicians have signed on to contribute pieces for the second year. The articles that have appeared can be found on my website http://www.angelagibney.org/the-early-career/.

- I have been a Co-PI for NSF funded programs for grad student training:
  - RTG Grant (DMS-1344994) http://bit.ly/2cW8iES;
  - VIGRE Grant (DMS-0738586) http://www.angelagibney.org/at-uga/.
- I have co-organized a number of conferences and workshops, including:
  - 2018 Algebraic Geometry Northeast Sectional meeting, AGNES http://www.agneshome.org, (with Borisov, Buch, and Krashen);
  - 2016 Moduli of Sheaves and their enumerative geometry http://bit.ly/2pK1iFT, (with Deopurkar, Kass, and Tarasca);
  - 2015 Bootcamp for the Alg Geom Institute in Salt Lake City, Utah (co-organized with Coskun, Lieblich and DeFernex) http://bit.ly/2cEuRjz. Funding from NSF and NSA came through UGA;
  - several years of GAGS, the Georgia Algebraic Geometry Symposium http://people.math.gatech.edu/~jrabinoff6/gags2018/, (2010, 12, 13, 14, 17);
  - the 2004 MRC Program in Snowbird, Utah http://bit.ly/30NiAin (co-organized with Abramovich, and McKernan).

- I will speak and have spoken at numerous conferences and workshops for graduate students, most recently:
  - in 2020, Madison Moduli Weekend, Madison Wisconsin, http://bit.ly/2VfFnlv organized by graduate students Brandon Boggess and Soumya Sankar;
  - in June 2018, (5 invited) lectures at the Geometry of Moduli Spaces of Curves Summer School, http://indico.ictp.it/event/8319/ International Center for Theoretical Physics, Trieste, Italy;
  - in June 2017, (4 invited) lectures at GAeL, Géométrie Algébrique en Liberté, http://gael-math.org/aboutgael, in Bath, UK.
- I have served on a number of professional development panels at conferences and workshops including the Graduate Advising Workshop at Ohio State University (June 2019); and at MAAGIC (the Mid-Atlantic Algebra, Geometry, and Combinatorics Workshop), among others.

Outreach

Activities that get kids on campus, into the math department or around mathematicians can help them consider a future in STEM. I have been involved in a number of such programs, including:

Women in math

- I have spoken at conferences for female students and postdocs including:
  - *Workshop on math advice and networking at the University of Pennsylvania*, a conference for undergraduate women to prepare for grad school in math. http://bit.ly/2OknAZ6 September 2019;
  - I spoke on a panel about careers involving mathematics, representing careers in academia, at the 2019 High-school Girls Career Pathways Conference, S. Brunswick, NJ;
  - *Strength In Numbers: a graduate workshop in number theory and related areas*, http://bit.ly/2OkG37T at Queen's University, in Kingston, Ontario, 2018;
  - *the Graduate workshop in Algebraic Geometry for Women & Mathematics of Minority Genders*, https://sites.google.com/view/GWAG Harvard and MIT, in Boston, MASS, 2017;
  - *Women in Science Seminar* at the IAS Women's program in Princeton, NJ. 2007;
- I have co-organized conferences for women mathematicians, including:
  - In 2015, (with Linda Chen), special session in Algebraic Geometry for the bi-annual AWM Research Symposium, http://bit.ly/30I3SsZ, University of Maryland;
  - In 2009, (with Diane Maclagan and Jessica Sidman), the Connections for Women Conference at MSRI http://www.msri.org/workshops/471;
- I have participated in AWM Chapter activities, helping to start and run an AWM chapter at Rutgers in 2017 http://sites.math.rutgers.edu/~cy257/AWM.html, and from 2010 -2016, being faculty contact of an AWM Chapter at UGA;
- I was an Enhancing Diversity in Graduate Education mentor (EDGE) http://bit.ly/2cW7j7I.

Younger students

- with Krashen, I designed and ran UGA MathCamp http://torsor.github.io/mathcamp/, which brought local high-school students to the math department at the UGA for one week of activities in the summer (2013,14,16, and 18). We hosted a diverse group: generally 50% female, 40% minority students;
- with Krashen, I designed and ran a program *Mentoring and Advice for Talented Highschool Students*. These M.A.T.H. Students were paired with graduate students for a one semester reading project and would regularly visit UGA and got to see first hand what it was like to study for a PhD in math. Each student and their school received money for books.
- I lectured at the high-school Summer Stem Academy http://bit.ly/1PPQzKR (for two summers);
- I volunteered at the King/Chavez/Parks College Day Visitation Program http://bit.ly/2cxTdL5, where 7th and 8th graders from Detroit visited U of Michigan for a day of activities to promote interest in STEM;
- as a grad student at UT Austin, I co-organized the Saturday Morning Math Group, https://www.ma.utexas.edu/users/smmg/, a program for high school students at UT.

Teaching

Beyond teaching the standard undergraduate and graduate curriculum, I have had the opportunity to engage in a number of special programs, courses, and events, some of which I briefly describe below.

Topics Courses

1. **Toric varieties:** Toric varieties are those on which an algebraic torus acts with a dense orbit. They are particularly good examples to study when learning algebraic geometry, as many of their properties are completely determined by combinatorial information, and examples are in abundance. In this class, we used Fulton's book on toric varieties as well as lecture notes from various authors, to learn the basics. Students each gave a talk on something related to toric varieties.
2. **Quantum cohomology:** The quantum cohomology ring is a generalization of the ordinary cohomology ring of a closed manifold. In the quantum cohomology ring, ordinary intersection numbers, which count how subspaces intersect, are replaced by quantum cup products, which count curves. In this class the main applications were to Kontsevich's formula for rational plane curves, and to computing the Verlinde formula for type A conformal blocks, via Witten's theorem, using elementary quantum cohomology in the Grassmannian. The course was computational, full of examples, and very concrete.
3. **The moduli space of curves $\overline{\mathcal{M}}_{g,n}$:** Moduli spaces of curves occupy a distinguished position in algebraic geometry: They give insight into the study of smooth curves and their degenerations, they have played a principal role as a prototype for moduli of higher dimensional varieties, and as special varieties, they have been one of the chief concrete, nontrivial settings where the nuanced theory of the minimal model program has been exhibited and explored. In this course we studied $\overline{\mathcal{M}}_{g,n}$, the moduli space of stable n-pointed curves of genus g.
4. **Conformal blocks from integrable modules over affine Lie algebras on $\overline{\mathcal{M}}_{g,n}$:**

   The moduli spaces $\overline{\mathcal{M}}_{g,n}$, admit dual vector bundles of coinvariants and *conformal blocks* defined by integrable modules (at a fixed level) over affine Lie algebras. There is a canonical identification of vector spaces of conformal blocks with global sections of certain line bundles on moduli (stacks) of vector bundles on curves, a fact known for smooth curves for some time. Combinatorial aspects of the moduli space of curves reflect underlying geometric structures embodied by vector bundles of conformal blocks, and

properties of these vector bundles have been discovered using the combinatorics of the moduli of curves. In these lectures, my goal was to feature this interplay, and to point out open questions on each side.

5. **Invited graduate lecture series on classical vector bundles of conformal blocks**:

   (a) (2018) 5 lectures at the Geometry of Moduli Spaces of Curves Summer School, International Center for Theoretical Physics, Trieste, Italy http://indico.ictp.it/event/8319/

   (b) (2017) 4 lectures at GAeL, Géométrie Algébrique en Liberté, https://sites.google.com/outlook.com/gael/home?authuser=0, in Bath, UK;

   (c) (2013) 5 lectures at a summer school https://conformalmoduli.sciencesconf.org/ Universita Sapienza, Rome, Italy

The Graduate Student Mock AMS Conference

I developed and ran the Graduate Student Mock AMS Conference, a program intended to train graduate students in the art of giving a successful twenty minute general audience research talk. This activity was run as a seminar, and participants earned three credit hours. First and second year students often gave talks where they presented a subject covered on one of their qualifying exams. More advanced students spoke about their research. It was an excellent community building and training exercise. I believe this would be an excellent addition to any graduate program.

Graduate Student Teaching Training Seminar

In response to feedback from the graduate students who felt their current summer teaching training was too long winded and ineffectual, I redesigned some aspects of the teaching training program. With the new regime, each student gave a lecture, videotaped by a partner, watched by the pair together. Each student wrote: (1) a syllabus on an undergraduate or graduate class of their choosing; (2) a collection of tests to go along with their syllabus; and (3) a job application teaching statement. Students were also required to read another person's syllabus, tests, and teaching statement, and give verbal feedback.

Algebraic Geometry VIGRE Research Groups (VRGs)

In an effort to train graduate students in how to carry out a research project, as part of the VIGRE training grant, we instituted regular graduate student research training groups, referred to as VRGs. I was involved with four VRGs, two of which are briefly described below.

1. In this VRG, held in Spring 2009, we studied a family of level one conformal blocks divisors on $\overline{\mathcal{M}}_{0,n}$. Our observations have appeared in a paper that has been published in the International Mathematical Research Notices, which I describe in my research statement. We used numerical data obtained via Maucaley2 to formulate ideas about the family, and the proofs mainly involved linear algebra, accessible to the students.

2. During the AY 2014 -15 I held a VRG about an open problem for classical conformal blocks. The problem was to determine whether or not bundles for $s\ell_3$ of positive rank with level below the theta and critical levels, have nontrivial first Chern class. This result holds for $s\ell_2$, and is known not to be true for $s\ell_4$. So the $s\ell_3$ case is interesting as it would complete the picture. Ranks of such bundles can be computed with Schubert calculus, and determining which bundles had nontrivial rank was to play a big role in the approach we were planning to take.

   Students took the first semester to learn Schubert calculus and necessary background. In second semester, the students designed experiments using Maucaley2 which led them to postulate that the $s\ell_3$ picture is analogous to $s\ell_2$. A subset of students went on to investigate their conjecture.