

REGENTS' TEACHING EXCELLENCE AWARD NOMINATION

Department of Mathematics

CONTENTS

| Nomination Letter | 2 |
|--------------------------------------|----|
| Program Narrative | 4 |
| Departmental Fact Sheet | 7 |
| Evidence to Support Award Nomination | 8 |
| Departmental Culture | 8 |
| Student Success | 11 |
| Extended Impact | 15 |



Sr. Vice President for Academic Affairs & Provost Administration Building, 203 220 S. Jackson St. Athens, Georgia 30602 TEL 706-542-0415 provost.uga.edu

USG Regents' Teaching Excellence Award for Department or Program Committee 270 Washington Street SW Atlanta, GA 30334

Dear Members of the Teaching Excellence Award for Department or Program Committee,

It is my great pleasure to write this letter of support on behalf of the Department of Mathematics at the University of Georgia for the USG Regents' Teaching Excellence Award for Department or Program. The Department of Mathematics has worked carefully and strategically to transform the math pathway for STEM students through the incorporation of inclusive teaching practices and active learning pedagogies, establishing a departmental culture of instructional efficacy and excellence, and creating learning environments dedicated to the success of individual students. Notably, the department has focused on the development of all instructors as reflective practitioners of evidence-based pedagogies, an extensive mentoring program for new instructors, and an instructional corps that is actively engaged in the conversation of teaching excellence in support of student academic success. These extraordinary efforts have led to remarkable gains in the success of Pre-Calculus and Calculus students at UGA. For these reasons and many others, UGA's Department of Mathematics is an excellent choice for the Regents' Teaching Excellence Award for Department or Program

The dramatic improvement in student success metrics underscores the impact of the transformation the Department of Mathematics has undertaken. For students taking Pre-Calculus at UGA, the DFW has dropped from 35% six years ago to 8% in Fall 2020. For context, the average national DFW rate for students taking Pre-Calculus is 27%. Similarly, the DFW rate for students taking Calculus I has dropped by 12%, along with a 3% increase in enrollment in Calculus II during the semester following enrollment in Calculus I. As a result, approximately 600 more students are passing Pre-Calculus, and another 150 are passing Calculus every academic year. Now, 750 more students each year are eligible to pursue majors that prepare them for high-demand careers in the sciences, business, and engineering without delay.

The Department of Mathematics began its educational transformation of introductory STEM pathway courses in 2016 as part of UGA's Small Class Size Initiative, which reduced class size from an average of 38 to 19 or fewer students in each section. To support the increased number of Pre-Calculus (MATH 1113) and Calculus I for Science and Engineering (MATH 2250) sections taught each semester, the department instituted structural and curricular changes, including flipping these courses and developing assessments as a team to ensure continuity and consistency across all the sections. Teams of instructors for each of these courses participated in an intensive course redesign institute during which MATH 1113 and 2250 were transformed from a lecture-based to a learner-centered active learning format. In addition, the department collaborated with the

UGA Libraries to produce the course workbooks developed during the institute at a low cost (<\$20 per copy) while also replacing the course's commercial textbook with an open educational resource from OpenStax.

The increase in student success is also a reflection of the increase in instructor efficacy and development within the department. New instructors are paired with a mentor from the senior instructional corps who provides consultation and guidance for the developing instructor, conducts peer teaching observations and delivers feedback, and provides a longitudinal perspective of instructional growth for tenure and promotion. In addition, each pathway course (e.g. MATH 1113) has a team of instructors who meet regularly to discuss the curriculum, assessments, and any changes to the overall instructional design of the course. Graduate student instructors not only participate in these team meetings but are provided with in-depth training in active learning pedagogies, assessment methods, and the revised curriculum developed by Department of Mathematics faculty. New and experienced instructors, graduate students and tenured faculty alike, are encouraged to attend the bi-weekly seminar series run by the department, in which participants discuss literature on teaching and learning and insights and roadblocks encountered in their own courses.

STEM faculty from across UGA, including the Department of Mathematics, were recently awarded an NSF IUSE grant entitled Department and Leadership Teams for Action to promote institutional change in STEM teaching practices. To date, the Department of Mathematics Instructional Action Team has introduced a new structure for the annual evaluation of instructors that includes peer-observation of teaching and the instructor's self-reflection on their teaching efficacy and plans for future growth.

The Department of Mathematics at UGA is a leader in evidence-based practice, educational development, and student success. I believe it is highly deserving of the Regents' Teaching Excellence Award for Department or Program.

Sincerely,

X.Au

S. Jack Hu Senior Vice President for Academic Affairs and Provost

Narrative Statement

Purpose & Philosophy:

The Mathematics Department at UGA is a regional leader in the national effort to transform post-secondary education in mathematics by embracing evidence-based, student-centered teaching strategies throughout its curriculum. The department is instrumental in the academic success of all UGA undergraduate students (approximately 30,000), and approximately 12,000 STEM undergraduate majors. Every undergraduate STEM major, regardless of school or college, is required to take either MATH 1113 or MATH 2250. These pathway courses enroll an average of 3,500 students each year. Recognizing the instrumental role of these courses in preparing a diverse workforce and seeing an opportunity to bolster the success of all students pursuing degrees in science and engineering, the department transformed the structure, curriculum, and instruction of the Math-STEM pathway courses.

In this nomination, our vision for this transformation and activities related to its actualization will be referred to as the Math-STEM Pathway Program (MSPP), although this work was never formally titled. MSPP focuses on supporting student success equitably so that every UGA student has the opportunity to pursue a degree in STEM.

<u>Program Mission & Goals:</u> MSPP's overarching mission is to establish a culture of teaching excellence and efficacy within the department in order to create classroom climates conducive for the learning of all students. To support student success through excellence in teaching and learning, MSPP has two interconnected goals:

- 1. Increase student success and learning in STEM pathway courses the first time they are taken.
- 2. Build capacity for mathematics instruction in higher education within and beyond UGA.

<u>Key Strategies & Initiatives:</u> To achieve our goals, MSPP created an infrastructure for the organization, planning, structure, and curricular redesign of MATH 1113 and 2250. The department established programming to foster best practices and build active learning among our instructional corps and created a mentoring and training program for new instructors. The department also funded faculty participation in national programs such as CoMinDs and Project NeXT, and encouraged participation in professional development opportunities at UGA, such as Faculty Learning Communities and the Active Learning Summer Institute.

Robust Course Coordination: In Fall 2016, the department adopted the recommendation and best-practices of the Mathematical Association of America to provide more robust coordination in Calculus I. Recognizing the value of robust coordination in STEM pathway courses, the department moved to an instructional team approach in the coordination Precalculus (MATH 1113).

Instructional Teams: The Association for Supervision and Curriculum Development advocates the intentional use of instructional leadership teams for effective and efficient curricular change.

Instructional teams were established to develop resources and curriculum for STEM pathway courses as part of UGA's Active Learning initiative. These teams are also responsible for preparing instructors in these courses to use curricular resources and active learning pedagogies effectively and provide them opportunities to discuss successes, surprises, and difficulties in their teaching at weekly team meetings.

Adoption of Active Learning Pedagogies: Extensive literature on teaching and learning demonstrates the positive impact of active learning pedagogies on student learning and success. In 2018, the faculty leaders of the STEM pathway instructional teams participated in the Active Learning Summer Institute. The teams developed aligned and embedded student-facing learning outcomes at the course, module, and lesson levels, scripted and recorded instructional pre-class videos, and wrote companion workbooks for students (of several hundred pages in length!). Active learning has become one of the central precepts of departmental instruction.

Open Educational Resources & Low-Cost Materials: The average cost of textbooks in a STEM undergraduate course is \$140. Students enrolled in STEM pathway courses in Mathematics are often taking 2-3 other STEM courses in addition to MATH 1113 or 2250. To increase equity and diversity among STEM majors, the department transitioned to open educational resources (OpenStax) in lieu of a commercial text for the pathway courses. This adoption saved students in MATH 2250 (Calculus I) more than \$300,000 last academic year. The department partnered with the University Libraries to print workbooks for MATH 1113 and MATH 2250, developed during the Active Learning Summer Institute, at half the cost of a commercial publisher.

Small Class Size: Another best-practice the department put into place was to increase the student-instructor ratio in STEM pathway courses by reducing the size of each section and offering more sections each semester. Beginning in 2015, sections of MATH 1113 and 2250 are capped at 19 students.

Training of Graduate Student Instructors: In order to support the number of sections of STEM pathway courses being taught each semester, the department developed a robust program for the instructional development of its graduate student instructors. Key aspects of the program include three semesters of seminar-style courses designed to provide training in multiple modalities and active learning pedagogies. In addition, during each these three semesters, graduate student instructors are observed twice each semester by the course coordinator, and provided with encouragement, support, and feedback related specifically to their teaching.

Individualized mentoring: Commitment to instructional excellence extends beyond graduate student instructors to include faculty and post-docs new to the department and its culture of active learning. Every new instructor is paired with a faculty teaching mentor during their first semester, and that relationship provides encouragement, coaching, feedback, and a longitudinal perspective on the mentee's development as an instructor.

Professional Development: Beginning in 2017, the department created department-wide instructional development opportunities, such as the Mathematics Learning and Teaching (MaLT) seminar. The department also allocates funding for faculty to participate in national educational development programs, such as the Mathematical Association's Project NeXT and CoMInDS.

<u>Summary:</u> The mission of MSPP to establish a culture of teaching excellence and efficacy to create classroom climates conducive for the learning of all students has transformed the department. Systematic and strategic implementation of evidenced-based teaching practices and commitment to equity and diversity facilitated increased students' success and learning in STEM pathway courses and built capacity for mathematics instruction within and beyond UGA.

Fact Sheet

The Department of Mathematics at the University of Georgia offers B.S., M.A., Master of Applies Mathematical Sciences (M.A.M.S.), and Ph.D. degrees, in addition to 5-year combined B.S. and M.A. double-degrees in Mathematics. Mathematics is the language of science, and mathematical reasoning is essential to solving real-world problems in most professions. The department is critical to the mission of UGA and the University System and is dedicated to providing all students with the skills, knowledge, and application of mathematics essential for their success at UGA and beyond.

Instructional Corps: The core faculty in mathematics is composed of 33 tenure line and 25 fulltime instructional faculty. The instructional corps also includes 16 post-doctoral scholars and limited-term Assistant Professors, and 33 graduate student instructors. One quarter of the instructional corps are women and 8% represent ethnic minorities in mathematics.

The commitment of the department to instructional excellence is recognized at the national, system, and university level. Faculty have been awarded the Louise Hay Award by the Association for Women in Mathematics, the Mary P. Dolciani Award by the Mathematical Association of America, the Excellence in Teaching Award by the USG, and the Richard B. Russell Award for Excellence in Undergraduate Teaching by UGA. The department also boasts 3 Josiah Meigs Distinguished Teaching Professors, 3 Lothar Tresp Outstanding Honors Professors, 4 Sandy Beaver Teaching Professors. Other awards include the Creative Teaching Award (2), Sandy Beaver Teaching Excellence Award (11), Outstanding Teaching Assistant (50), and Graduate Instructor Award (21).

Curricular Role: The department is integral to the success of all UGA students – teaching the Area 1 Foundation Courses common across the USG, the required entry courses for 157 undergraduate majors across 6 schools and colleges, and courses required in an additional 41 undergraduate majors. Each year the department teaches over 4,000 students in these pathway courses.

Students: Over the past five years, an average 46 Ph.D. students, 6 masters students, and 266 undergraduate mathematics majors, have enrolled at UGA each year. About 42% of undergraduates are women, and 9% represent ethnic minorities in mathematics. Each year approximately 30 undergraduate students participate in mathematics research opportunities with departmental faculty and graduate students. Graduate student contributions in the last 6 years include 34 peer-reviewed articles by graduate students, 29 articles authored by graduate students and faculty, 11 articles authored by graduate students and post-docs, and 2 articles authored by graduate students.

Evidence to Support Award Nomination Part I: Departmental Culture

The MSPP has built a departmental culture of instructional excellence, and mentoring and training of new instructors. This aligns with the goals of the MSPP to improve success in gateway courses, and build instructional capacity. The growth of a student-centered instructional culture directly benefits UGA students. Moreover, the roughly 10 postdocs and graduate students who leave UGA's Mathematics Department each year for positions elsewhere bring the benefits of their MSPP mentoring and training to the larger educational community.

Faculty Training through Course Coordination

Most new faculty begin their teaching at UGA with one of the coordinated courses on the STEM pathway, MATH 1113 or MATH 2250. The course Coordinators provide structure and resources for these instructors and lead regular instructional meetings which provide coaching for effective teaching and give opportunities to address concerns. A former Limited Term Assistant Professor praised the effectiveness of the MATH 2250 coordination and the extensive mentoring provided:

"Dr. Royal did a remarkable job as a course coordinator. Each time, before a semester began, she sent out a complete package to us covering everything an instructor needs. On top of the essential topics to be covered and syllabus template, I find it very useful that she also sent use a daily template so that people who teach the course for the first time will have a good grasp planning for the entire semester. In the biweekly 2250 instructors meeting, Dr. Royal often started with teaching tips and went through common pitfalls for specific topics. For example, related rates problems are not easy to teach in an organized manner without a careful preparation. Dr. Royal provided us her handouts with a memory aid which saved us much time for the unit. In addition, Dr. Royal also paired up new and graduate instructors with experienced ones in our meetings, which I find helpful since everyone gets to be involved. In contrast, from my personal experience as a graduate instructor at the University of Virginia, we did not receive such teaching aids."

Training of Graduate Student Instructors

The training of graduate students who serve as course instructors is centered around the key MATH 1113 and MATH 2250 courses. This training includes three semesters of "shadow seminar courses", which are seminar-style courses associated with the gateway MATH 1113 and 2250 courses. During their first year, graduate students teach MATH 1113 using the flipped materials developed during the Active Learning Institute. During the first semester of their second year, they teach MATH 2250, and can choose between a flipped format or a traditional lecture format; most are currently opting for the flipped format. During each of these three semesters, graduate student instructors are observed at least twice each semester, and provided with encouragement, support, and advice during a post-observation extensive debriefing.

Mentoring of Instructors

The department's Mentoring Committee pairs each new faculty member with a faculty mentor who makes classroom observations and provides consultation and guidance for the developing teacher. The Mentoring Committee also assists by providing guidance on how to conduct peer observations of classroom teaching. In the words of a Limited Term Assistant Professor about the mentoring program:

"During Fall 2019, I taught MATH 1113 for the first time. Throughout the semester, Toyin was always eager to share her materials and insights about teaching and helped me whenever any questions or issues arose and I have always been amazed at her resourcefulness and knowledge. Toyin always has great ideas about how to gauge students' progress and engagement. One particular thing that comes to mind is Toyin's Exam Reflections worksheet that she developed for MATH1113 and MATH2250. I thought it was a great idea and allowed students to reflect on their learning and studying habits. This past year, Toyin and I had many conversations about ways to improve on various assignments and activities in our classes. We frequently reviewed each other's quizzes and group activities and shared thoughts on them. Toyin always has great ideas about ways to make activities more centered around active learning and I often incorporated her advice and ideas in my teaching practice."

In Fall 2021, the Mathematics Department asked instructors to rate departmental training and mentoring. Instructors were asked to respond, on a scale from "Strongly Disagree" to "Strongly Agree", to the statement: "The mentorship and guidance I have received from the UGA Mathematics Department has been helpful in improving my teaching." The results are shown in chart 1.

The mixed responses from tenure-track faculty indicate a direction for





departmental improvement. The strongly favorable overall response demonstrates that instructors value departmental mentoring and training. All of the graduate students and instructional faculty, and all but one postdoc, responded with "Strongly Agree" or "Agree".

Positive comments included the following:

The mentor-mentee system has worked out very well for me. I have had an incredible mentor for the last three years and learned a lot from her. It's great to have someone you can turn to for questions and advice.

I think Toyin Alli has done a great job organizing and formalizing the teaching mentor system. This is not directly related, but I am also very grateful to her for all the work she has put into developing a flipped precalculus class, and for her generosity in sharing her materials with the department.

I felt that Dr. Black's MATH 9005 course was an invaluable resource for me as a new teacher, and I am thankful that the Department provided with an opportunity to participate in such a course.

Departmental Professional Development

The Mathematics Active Learning Team (M.A.L.T.) seminar was established to disseminate best practices involving active learning throughout the Department. To broaden the discussion, the seminar has evolved into the Mathematics Learning and Teaching seminar and includes participants and speakers from other Departments. Participants meet to discuss key works in the literature, to hear from experts in the educational community, and to discuss insights and roadblocks instructors encounter in their own courses.

Since 2019, professional development within the department has been led by co-PIs on a 5-year NSF IUSE grant entitled DeLTA: Department and Leadership Teams for Action, through an Instructional Action Team. The DeLTA grant involves multiple STEM departments, and aims to promote institutional change towards evidence-based teaching practices. At present, the grant is funding eight mathematics faculty to learn about and develop evidence-based teaching practices in their own classrooms, and to share their materials and expertise throughout the Department. The Department Head also participates in DeLTA's Leadership Action Team, helping to change instructional practices to encourage improved teaching. For instance, because of the Head's leadership, the department initiated faculty self-reflection on teaching as part of annual reviews.

Center for Teaching and Learning Activities

Many department members have been involved with activities sponsored by UGA's Center for Teaching and Learning (CTL). These activities help build capacity for STEM education by sharing mathematics faculty expertise across the university. They also directly enrich mathematics instruction. Notable activities include:

- Six faculty members participated in UGA's Active Learning Summer Institute, redesigning our important Precalculus, Calculus I, Calculus II, and Mathematical Modeling courses.
- Jennifer Royal led a Coordinated Course Faculty Learning Community. Participants came from all over campus, with much STEM participation, and some from languages (Spanish & French). They created a repository of resources for coordinated courses, including documents focused on best practices, assessment in coordinated courses, and a snapshot of current practices.
- Toyin Alli led an FLC on *Collecting (& Analyzing) Data on Student Learning in Active Learning Classrooms*. Participants looked carefully at the work/artifacts students were generating in active learning classrooms, to make judgments about instruction and student learning. Dr. Alli is currently participating in CTL's SoTL [Scholarship of Teaching and Learning] Scholars program.

Other Professional Development

The Mathematics Department encourages – and funds – departmental participation in professional development activities. Two junior faculty members are currently receiving department funding to participate in Project NeXT, a professional development program of the Mathematical Association of America for new and recent Ph.D.s. The department provided funding for two faculty members to attend a CoMinDs workshop on approaches to training and mentoring graduate students. Another faculty member is currently participating in the PIC Math (Preparation for Industrial Careers in Mathematical Sciences) program. This program trains faculty members to prepare students for industrial careers, by engaging students in problems which come directly from business, industry or government.

Enhancements to Faculty Evaluation

Instructional excellence is defined in the Mathematics Department as providing an environment that facilitates learning, encourages achievement, is supportive of students, and responsive to feedback and evidence. The excellence, efficacy, and implementation of evidence-based teaching practices is assessed annually through "three voice" combination of peer evaluation, student evaluations, and personal reflection.

The third voice – personal reflection – was introduced in Spring 2019. Starting that term, faculty members were asked to submit a reflection on their teaching as part of their annual evaluation materials. This change was recommended by a committee consisting of department members and participants in the DeLTA project.

The self-reflection is designed to promote continuous teaching improvement, and is a source of documentation of teaching accomplishments that aligns with the recently revised UGA Guidelines for Appointment, Promotion, and Tenure. In Fall 2021, members of the DeLTA group visited a departmental meeting to provide guidance on making self-reflection productive. They suggested that instructors identify a teaching issue, gather data, and use data to address the issue, and then use the description of this process as their teaching reflection. This process clearly promotes improvement.

Within the past two years, the department has implemented separate evaluation committees for instructional faculty and tenure-stream faculty. Expanding the role of instructional faculty has improved the evaluation process. Moreover, faculty are now more aware of the contributions of their colleagues. This helps foster a culture of commitment to fine teaching.

Recognition of Instructional Excellence

The department seeks to recognize and reward good teaching. In 2019, we introduced an annual Departmental Teaching Award, and this year plan to begin an annual Postdoctoral Teaching Award, to recognize outstanding teaching among our cohort of 16 postdocs and Limited Term Assistant Professors. Each year, we select several graduate student instructors for Outstanding Teaching Assistant awards, and the most exceptional is recognized by the David Galewski Outstanding Graduate Teaching Award.

The Department offers opportunities for advancement as a reward to outstanding teaching. In 2021 three of our outstanding Lecturers were awarded early promotion to Senior Lecturer. The previous year, two Instructors received Lecturer appointments in recognition of their excellent teaching and other contributions to the instructional mission, including service as Undergraduate Coordinator and Online Course Coordinator. These actions reflect the core values and Departmental culture of instructional excellence.

Part II: Student Success

The MSPP aims to increase student success and learning in STEM pathway courses the first time they are taken. Data shows that the MSPP is working: we are pleased to report dramatic reductions in DFW rates, and improvements in equity and student satisfaction.

Instructional Efficacy

Data from Fall 2016—the year the transition in Precalculus and Calculus began—showed a marked improvement in DFW rates. This improvement has continued. In Fall 2015, the Precalculus DFW rate was 33%, falling to only 15% the following year, and continuing to decrease to 9% in 2019. According to the Mathematical Association of America, the national

average DFW rate for Precalculus is 27%. The difference is exceptional and means greater success for hundreds of students. The DFW rates in Calculus have also shown improvement, although it is not as drastic. The Fall 2019 decrease to 13% is strongly encouraging.





Graph 1: DFW rates in MATH 1113 & MATH 2250 compared to national average.

Although data from Fall 2020 is not truly comparable to data from previous fall terms, due to the hybrid nature of pandemic mathematics instruction, it is worth noting that the DFW rates in both Precalculus and Calculus fell even further in Fall 2020, to 6% and 10%, respectively. This is a notable success in a challenging instructional environment.

The results in the next course in the sequence, MATH 2260, showed a notable improvement up to Fall 2019, with improved grades and DFW rates. However, in Fall 2020, the trend reversed, with a rise in DFW rates. We believe this represents a temporary pandemic reversal of the overall positive trend. We believe that we will continue to see improvements in DFW rates in Calculus II as a result of students being better prepared in Calculus I, along with

improved teaching practices across the department. As we discuss below, these improvements have been made while maintaining instructional standards.

Improved Student Satisfaction

The improvements in instructional culture are not only showing up in grades, but in student

satisfaction with classroom practice. Chart 2 shows show student ratings on the end of course evaluation question about ``overall effectiveness" of the instructor, comparing averages before and after 2016. The highest rating, 5, is labeled ``Outstanding", and 4 is labeled ``Superior".

The evaluation data shows improvement from ratings that were already strong. The average score rose from 3.77 before Fall 2016, to 3.89



Chart 2: Student ranking of instructional efficacy.

afterwards. Notably, the number of students who gave their instructors the highest rating of ``Outstanding'' rose markedly and was almost 42% in the most recent period.

Successful Pandemic Instruction

The COVID pandemic led to drastic instructional changes across the department and university. In Spring 2020, all UGA classes were moved abruptly online with less than two weeks of lead time. Face to face instruction did not resume until Fall 2020, and during the academic year 2020-21, social distancing requirements dictated that classes were taught in a hybrid format where much instruction happened over Zoom. Anecdotal evidence indicates that during this period, many students felt a lack of connection and engagement.





The mathematics department faculty rose to the challenge. Lead instructors for each of the department's large multi-section courses helped facility to suddenly move online. The department's online course coordinator, Allison Arnold, provided especially valuable assistance to many instructors. By Fall 2020, instructors had gained valuable experience with technology, and their commitment to student success allowed them to engage students remotely. Student evaluation data bears this out. Chart 3 compares student ratings of instructors for overall effectiveness for the 2020-21 academic year with the

ratings over the Fall 2016-Spring 2021 period. One sees that despite the difficulties of pandemic instruction, during a year where much instruction was hybrid, students rated their instructors almost as highly as in the longer, mostly pre-pandemic period. This is a testament to a student-centered teaching culture, as well as to the dedication and skill of our instructional corps.

Improvements in Equity

The Department is also pleased to report that we are beginning to see a local confirmation of research reports that active learning strategies improve gender and racial equity. Charts 4 and 5 measure success rates in MATH 1113 and MATH 2250, respectively, by gender and race/ethnicity.







Chart 5a: Student Success – URM and 1st Gen







This data shows strong performance by female students in both precalculus and calculus. There are significant improvements in DFW rates for URM and first-generation students in both Precalculus and Calculus. Moreover, the disparity in DWF rates among racial/ethnic groups has been almost eliminated in Precalculus. We are committed to see this trend continue.

Increased Success While Maintaining Standards

The marked improvements in both grades and DFW rates in MATH 1113 and MATH 2250 are indicators of increased student success. However, the Department wanted to ensure that rigor and academic standards had been maintained. In order to evaluate student learning and retention of that learning, the Department looked at performance in subsequent courses.

In collaboration with the Office of Institutional Research, the Department evaluated the success of MATH 1113 students in MATH 2250, the next course in the sequence (Chart 6). Students



who took MATH 2250 but fulfilled their Precalculus requirement elsewhere were used as a control group. If MATH 1113 standards were decreasing, the students who took MATH 1113 would be expected to show a trend of lower grades and higher DWF rates in MATH 2250, relative to the students who fulfilled their Precalculus requirement elsewhere.

The data clearly shows that the opposite is happening. While both cohorts show improvement over time in average grades and DWF rates, the improvement is *greater* among the students who took MATH 1113 at UGA than among the students who fulfilled their Precalculus elsewhere. This is strong evidence of improved instructional efficacy, while maintaining high standards of student performance.

Part III: Extended Impact

By improving teaching and building instructional capacity, the MSPP program has had the ripple effect of fostering enhancements to the entire mathematics program. The postdocs and graduate students who receive training and mentoring through the MSPP play a significant role in these enhancements.

Additional Math Pathway Development

MSPP's student-centered commitment to excellence and the resulting departmental culture of instructional excellence inspired the department to innovate and adopt best practices for additional math pathways. In Fall 2019, the department introduced a Double Dawgs B.S./M.S. program pairing an Applied Mathematics Area of Emphasis with a Masters of Applied

Mathematical Sciences degree. An Area of Emphasis in Mathematical Finance is expected to be approved by the University Council in Fall 2021. Record numbers of students are engaged in mathematical research. A Math Peer Mentor Program (MP²) launched in Fall 2021 pairs new math majors with more senior student mentors, to build community, engagement, and ultimately, success in the major.

Connecting Mathematics to Real-World Problems

Two exciting new courses connecting mathematics to the real world will be piloted in Spring 2022: Linear Algebra and Data Science and a PIC Math course, designed to introduce students to problems drawn directly from business, industry or government. The PIC partners in Spring 2022 will include the Food Bank of Northeast Georgia; students will model food scarcity, and provide insights into distribution by location.

Online Course Development

Development of flipped STEM pathway courses continues in the Mathematics Department. A flipped version of MATH 2260 (Calculus II) was created during the 2019 Active Learning Summer Institute and are pilot versions of flipped MATH 3300 (Applied Linear Algebra) and MATH 3200 (Introduction to Higher Mathematics). During the rapid transition to virtual instruction in Spring 2020, the Department's investment in flipped course materials proved invaluable for instructional continuity and student learning. MATH 2250 instructors were able to use the flipped classroom materials seamlessly; the video content was already well-adapted for virtual instruction, and the in-class group work was easily replaced by interactive Zoom sessions.

Being well-suited to both hybrid and fully online formats, materials developed for these courses will be useful beyond the fully online format, providing supplemental material for face-to-face and hybrid instruction.

Mathematical Modeling (MATH 1101)

Mathematical Modeling (MATH 1101) is an important core course, fulfilling an essential general education requirement for non-STEM students. It is the only class taught by the Mathematics Department in large sections of close to 100 students. One of the lead instructors for MATH 1101 participated in the 2019 Active Learning Summer Institute. There, he explored ways to inject the active learning ethos into MATH 1101 and redesigned both the instructional approach and materials. Since MATH 1101 is not part of the Small Class Size Initiative, active learning principles that scale to larger class sizes were used including: "pre-lecture" assignments designed to foster active engagement with new ideas and methods prior to in-class discussion; in-class learning activities using the game-based learning platform Kahoot; and learner-centered syllabus, lectures, assignments, and grading policies and procedures. The redesigned MATH 1101 was successfully piloted in Fall 2019, and materials made available to other instructors. To quote a student in MATH 1101 during Fall 2019:

"I've dropped this course like three times. It has always been tedious, but Mr. Miller I come to class for. He makes this stuff relevant."



Actively Remodeling Mathematical Modeling (MATH 1101)

and Learning

Erik Miller, Department of Mathematics



Enhancements to the Mathematics Major

The growth of a departmental culture of active learning has also enriched the mathematics major program. There are several examples in advanced courses of faculty moving away from

traditional lecture style classrooms to provide more student-centered learning in addition to the flipped versions of Introduction to Higher Mathematics (MATH 3200) and Applied Linear Algebra (MATH 3300). Faculty have introduced assessments involving group projects, providing opportunities for students to experience the mathematical concepts they are learning in a realistic context. For example, an instructor collaborated with a graphic design professor to develop an experiential learning course ``Math Outreach Design Lab". A model made in this course by three math majors and one graphic design major was featured on the cover of the prestigious Proceedings of the National Academy of Sciences and they jointly earned a Creative Teaching Award in 2020.



Figure 1: Mathematical model selected as the cover of PNAS.

New Degree Pathways

Two degree programs offer new opportunities for our students. With our Double Dawgs B.S.-M.A.M.S. program introduced in 2020, students can complete an undergraduate mathematics degree and Masters in Applied Mathematical Sciences in 5 years. An Area of Emphasis in Financial Mathematics, expected to receive final approval this fall, will train students in mathematics related to financial markets, and allow students to count selected Finance courses towards their mathematics degree.

Math Peer Mentor Program

Not long ago, an advanced math major mentioned to our Undergraduate Coordinator that she would have benefitted from a mentor as she began her studies. That conversation was the genesis of the Math Peer Mentor Program (MP²). Launched in Fall 2021, MP² aims to foster a peer learning space where math students from diverse backgrounds can engage and develop

Math Peer Mentor Program (MP)² This is a brand new peer mentorship program within UGA's Math department to provide a platform that inspires undergraduate Math students to cultivate camaraderie, growth, and connection to enhance their personal and professional development.

Starting in Fall 2021!

Mentor application is now open! https://ugeorgia.cal.qualtrics.com/jfe/form/SV_2ivqfbWoNKkKdeu



meaningful relationships within the department. Mentors will be able to reflect on their own student experiences, and hopefully, transmit information that provides valuable support. Mentees will be able to solidify their sense of belonging within the Math department through significant conversations and student involvement.

The inaugural group of participants includes 14 mentees and 7 mentors. We hope that this is just a beginning, and that peer mentoring will grow to become a significant part of the mathematics program.

Undergraduate Research Opportunities

During the 2019-2020 academic year, the Mathematics Department began to significantly reorganize its <u>Undergraduate Research Program</u> (URP). The aim of the Mathematics URP is to provide a no-cost, encouraging, stimulating venue for mathematics students at all levels to engage in meaningful research, reading and experiential learning projects – as well as to contribute to an equitable and vibrant research environment at UGA in all spheres: undergraduate, graduate and faculty. Our standard entry point for undergraduate researchers is the Directed Reading Program (DRP), which offers enthusiastic, highly-motivated undergraduate math majors the opportunity to learn advanced math topics in a structured, graduate-school-like environment. Participants spend a semester on an independent math project under the supervision of a graduate student mentor. Projects often take one of the following forms:

- An introduction to a subject not covered by the departmental coursework.
- An in-depth reading of a particular theorem or set of theorems.
- A more advanced treatment of a standard subject.

Building on existing research opportunities at UGA, the department established a Summer Undergraduate Mathematics Research Conference (SUMR). In August 2020, 20 undergraduates participated in the inaugural SUMR, which was held in a hybrid asynchronous and synchronous virtual environment using UGA's eLearning Commons platform (eLC). SUMR showcases the department's 10 undergraduate research groups and has led to joint undergraduate and mentor publications.

The Undergraduate Research Program continued to develop in 2021. In Spring 2021, five undergraduates were recipients of the first annual UGA Mathematics Undergraduate Research Award. This award recognizes graduating math majors or minors who have had strong participation in URP research groups by the program's award criteria -- including research mentor recommendation; multiple semesters' contribution to faculty research programs; and contribution to a conference presentation, paper, poster, or comparable participation in the research community. It is not a competitive award; it acknowledges undergraduate students who have reached outside the classroom setting, to make a contribution to our Department's research program.

Also that spring, the Geometry Research, Outreach and Visualization Initiative (GROVI, pronounced "Groovy") was started. The goal of GROVI is to produce a sophisticated computer animated video, of interest to everyone from the artistic public with an appreciation for geometric forms, to researchers in differential topology (Figure 2).

In Summer 2021, two instructors – including one postdoc -- ran an REU (Research Experiences for Undergraduates) on knot theory. Mathematically, a knot is like a tangled piece of rope with the two ends glued together. Knots can be used to describe many different kinds of phenomena in our natural world, such as the folding of proteins or genetic material. Despite perhaps a hundred or more years of study, there are still seemingly simple questions about knots that we still do not know the answers to. This REU introduced students to some of the basic tools and constructions in the field of knot theory, with the goal of generating new ideas for approaching some surprisingly open questions. Along the way, students learned how to interface with existing literature and how to communicate ideas to the scientific community.

Interest in undergraduate research remains high. During Summer and Fall 2021, over 20 undergraduates participated in URP projects. Students are presenting their work: In April 2021, 8 math projects were presented at the UGA's CURO (Center for Undergraduate Research Opportunites) spring symposium, and 17 students participated in the 2021 SUMR conference. The Undergraduate Research Program continues to thrive and provide important opportunities for mathematics students.



team.