THE UNIVERSITY OF ARIZONA
COLLEGE OF SCIENCE
Mathematics

Report of the Academic Program Review Self-Study Committee 2023-24

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Table of Contents

DEPARTMENT OF MATHEMATICS

ACADEMIC PROGRAM REVIEW

SELF-STUDY 2023

EXECUTIVE SUMMARY

The Department of Mathematics plays a central role at the University. We provide powerful tools and ways of thinking that contribute to every student's education. We carry out internationally respected disciplinary research across a wide swath of the mathematical sciences as well as interdisciplinary research and collaborations with many other fields. And we support our local community through robust engagement with the public and an extensive program of recruitment, development, and retention of teachers.

Over the last seven years, the department has met many challenges with energy and integrity, it has shown entrepreneurial creativity in developing new courses, degrees, and programs, and it has worked closely with partners in the College of Science and the broader university to advance the common good. In short, we have done everything that could be asked of us to advance the university's missions.

In order to continue doing so, two absolutely critical elements must be in place:

1) A commitment to replace all retiring faculty and to rebuild our research faculty to its natural size of 60 FTE. Over the last seven years, we have seen a generational change, with 16.5 FTE of retirements and resignations, matched by 16 FTE of new recruitment, leaving us with 52.5 FTE of tenure-track faculty. The departures include internationally prominent researchers whose work was the cornerstone of the Department's reputation, Regents' Professors, fellows of the main professional societies in our field, and winners of major international prizes. We are confident that some of the new faculty will go on to equal or greater height. However, the vast responsibilities we have taken on—such as playing a leading role in campus efforts around data science, supporting new degrees and international programs, and making major contributions to the GIDPs in Applied Math and Statistics and Data Science—require a larger faculty corps and imply a dire need to recruit. At the end of this academic year, about one fourth of our faculty will be at least 65 years old, so we can expect many retirements to come. Reinforcement is *essential*.

2) As requested, we have worked hard to develop programs and courses which are arguably outside the core mission of an R1, AAU research department, but which generate significant resources for the university and our college. These include a dual degree program in Beijing, professional master's degrees, a rapidly increasing number of online credit hours, and a large program of summer teaching. To date, a substantial fraction of the revenue from these programs has come back to the department, and these funds have supported things that are very important to our faculty and staff, such as postdoctoral scholars, graduate student stipends well beyond what is funded by "temp teaching", several staff positions, and operational funding for seminars, travel, computing equipment, furniture, etc. In short, shared revenue funds our quality of life. It is *imperative* that our ancillary efforts (international, professional MS, online, summer) result in a level of funding adequate to fill the gap between base salaries provided by the college and the research and infrastructure needs of a central and high-performance department.

A. SELF STUDY SUMMARY

This review covers the period from academic year 2016-17 to academic year 2022-23. In some cases, we present more recent data and/or start the analysis from Fall 2017, when the current department head was appointed.

A.1. Administrative Home

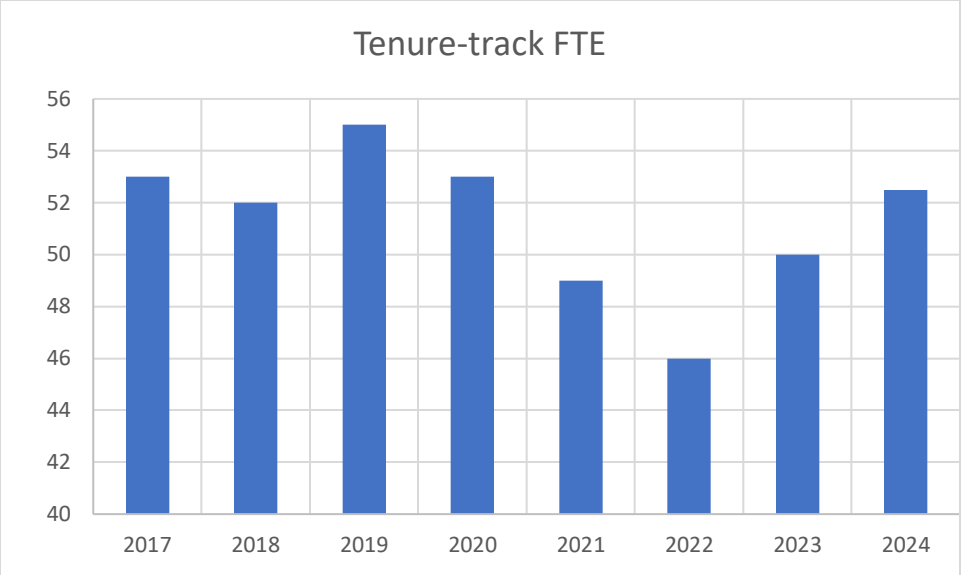
The Department of Mathematics is housed in the College of Science and is the home on campus for all intellectual activity in the mathematical sciences broadly construed: pure, applicable, and applied mathematics, as well as statistics and data science. The department has close connections to the Graduate Interdisciplinary Programs (GIDPs) in Applied Mathematics and in Statistics and Data Science. The "School of Mathematical Sciences" encompasses the department as well as the GIDPs. Although this review is of the department, the connections between the department, the school, and the GIDPs are essential to understanding the scope of our efforts. The department has offices, classrooms, labs, and seminar rooms in five buildings: the Math tower (MATH), the Math Teaching Lab (MTL), Environment and Natural Resources 2 (ENR2), Physics and Atmospheric Sciences (PAS), and Biological Sciences West (Biowest). The main administrative offices are in MATH.

A.2. Tenure Track and Continuing Status Faculty

As of Fall 2023, the department has 52 tenured and tenure-track faculty (50 FTE), and two continuing status faculty with ranks indicated in this table:

Academic Rank	Fall 2023
Tenured Professor	30
Tenured Associate Professor	15
Tenure Track Assistant Professor	7
Continuing Status Associate Research Scientist	2
Total	54

This graph shows the evolution of the number of tenure-track research faculty over the last six years:



Trends and goals for faculty hiring are discussed in more detail in Section E.

As of Fall 2023, there were 17 postdoctoral scholars, of whom 13 are fully department funded and four are partially funded by a Research Training Grant. We also have one Visiting Assistant Professor. The number of postdoctoral scholars in residence since FY 2016 is given table A.2.c.

FY	**2016**	**2017**	**2018**	**2018**	**2020**	**2021**	**2022**	**2023**
Postdoctoral Scholars	7	14	17	24	21	19	19	18

See section I2. for more details on our postdoctoral program.

A.3. Career-Track Faculty

The Department employs 50 faculty members in career track titles, distributed as follows:

Career Track Faculty	Fall 2023
Assistant Professor of Practice	1
Assistant Research Professor, Mathematics	1
Associate Professor of Practice	1
Global Professor (CUEB)	3
Instructor	22
Lecturer, Mathematics	10
Senior Lecturer, Mathematics	9
Visiting Assistant Professor, Mathematics	3
Total	50

The career-track faculty carry out the bulk of lower division teaching (from Math 100 to 302A/B), and one of the Professors of Practice runs our advising center.

A.4. Academic Programs

The department offers BA and BS degrees in Mathematics (with seven emphasis tracks) and BA and BS degrees in Statistics and Data Science. The number of students enrolled in each major, minor, and emphasis are given in the tables below.

Major	Fall 2022
Mathematics	334
Statistics and Data Science	201
Major Grand Total	535

Minor	Fall 2022
Mathematics	495
Mathematics (Teaching)	3
Statistics and Data Science	114
Minor Grand Total	612

The table below provides the distribution of majors in each emphasis for Fall 2022

Math Major Emphasis	Fall 2022
Applied (formerly General)	84
Comprehensive	44
Computer Science	38
Economics and Business	16
Education	46
Life Sciences	5
Probability and Statistics	24
Undecided/Undeclared	278
Grand Total	535

The table below provides the trends in enrolled majors since Fall 2016.

Major	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
Mathematics	576	590	550	450	391	355	334
Statistics and Data Science			50	123	183	192	201
Major Grand Total	576	590	600	573	574	547	535

The department also offers PhD and MS degrees in Mathematics. Essentially all graduate students are admitted to the PhD program, and the MS degree is mostly an off-ramp or a remediation strategy. PhD enrollment since Fall 2016 is given below.

Math PHD	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
Enrolled	52	55	58	54	47	50	55

The department makes essential contributions to the GIDPs in Applied Math and Statistics, with approximately 40% of our TA budget dedicated to students in those programs, and approximately half of the students in each program advised by Math faculty. See Section K for more details on the connections between the department and the GIDPs.

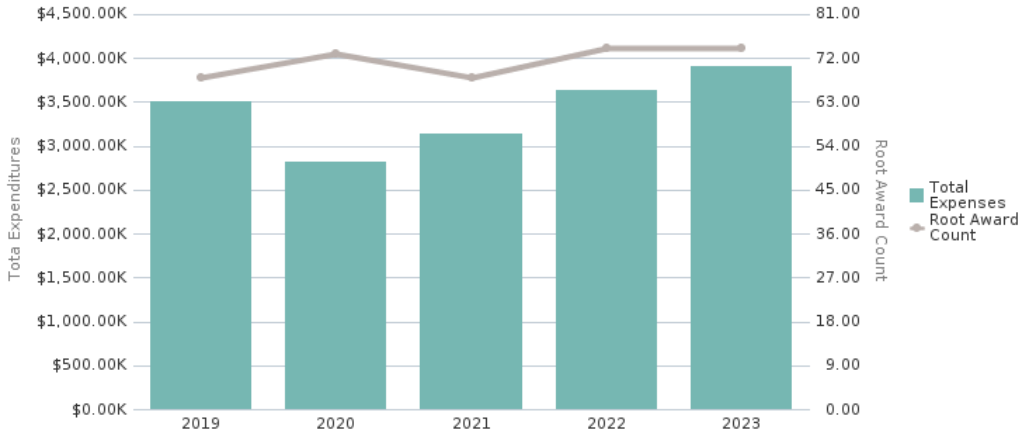
B. UNIT DESCRIPTION AND GOALS

B.1. Mission of the Department

The Department of Mathematics is the home for all intellectual and educational activity in the Mathematical Sciences at the University of Arizona. We carry out research and graduate/postgraduate education as befits a university classified as R1 and an AAU member. We have exceptionally broad connections to the rest of the campus, and a central and wide-ranging role in undergraduate education, both for our majors and for the spectrum of students on our campus (an HSI, Hispanic Serving Institution). And we have significant outreach efforts in support of the K12 system in southern Arizona and the broader, scientifically literate community around us.

- The largest segment of our teaching by SCH's consists of service courses, which can be divided roughly into (i) the highly developmental course Math 100; (ii) college-level courses for majors with modest needs in mathematics (College Algebra, Elements of Calculus, Basic Data and Statistics); and (iii) college-level courses for more math-intensive majors (such as Calculus, Statistics, and Differential Equations).
- We offer high-quality undergraduate majors (BS/BA) in Mathematics (with seven emphasis tracks) and Statistics and Data Science (SDS). The latter is growing rapidly and is being reworked as a broader Data Science degree with tracks in Statistics, Computer Science, and Molecular and Cellular Biology. Other tracks are under development. This degree is also offered in a dual-degree program with the Capital University of Economics and Business (CUEB) in Beijing.
- We offer a robust graduate program with PhD, MS, and MA degrees, and we provide major support in the form of courses and faculty advising to two Graduate Interdisciplinary Programs, namely those in Applied Mathematics and in Statistics and Data Science. Our faculty also contribute to other GIDP's such as Cognitive Science, Genetics, and Neuroscience.
- Our faculty carry out research at the highest international level, with strengths in areas including algebra, number theory, and algebraic geometry; PDEs, fluids, and applied, applicable, and numerical analysis; analysis, dynamical systems, and mathematical physics; statistics and data science; and mathematics education. Some of this research is carried out through the Southwestern Center for Arithmetic Geometry and the Arizona Center for the Mathematical Sciences. Grant awards in 2023 were about $4M and the number of research faculty with external support as PI or co-PI is 27 (out of 52 tenure-track faculty), with two new awards coming in Fall 2024.
- There were 14 patent applications and six patents awarded to Mathematics faculty during the review period.

- Grant Expenditures



- We contribute to the surrounding community through the Center for Recruitment and Retention of Mathematics Teachers (a grant-supported center that provides induction, professional development, and community building services for primary and secondary teachers of mathematics throughout Arizona), lecture series such as "Everything is Math" and the "Daniel Bartlett Memorial Lecture", as well as enrichment activities such as Math Circles and a program for Sonya Kovalevsky day.

B.2. Goals of the Department

- Continue to build faculty strength in key areas as we experience a period of retirements and transition. See Section L for a discussion of the recent strategic plan for hiring.
- Ensure that we have substantial and reliable streams of income (beyond College of Science support for salaries) which allow us to support our faculty and staff with equipment, space improvements, and operating funds for travel, seminars, and conferences. Such revenues currently come from online and summer instruction and the CUEB dual-degree program. Future streams are expected from Professional Master's degree programs in Data Science and Applied Mathematics.
- Continue to develop new tracks in the Data Science Bachelor's degree program.
- Increase the size of our postdoctoral program from its current corps of 15-20 postdocs to a corps of 30 (i.e., roughly ten new appointments per year). Increase stipends to remain competitive.
- Increase the size and quality of our PhD program. More competitive stipends will be required to enable the recruitment of well-qualified students.
- Engage donors to endow at least one additional faculty chair, endow one mid-career "term" chair, and name the CRR in honor of its founder, Fred Stevenson.

B.3. Contributions to the University Strategic Plan

Each of the five main pillars of the campus strategic plan is advanced by activity in the Department of Mathematics:

1) **WILDCAT JOURNEY:** "Preparing students with the skills and mindsets to lead in the 4th industrial revolution." Our courses provide enabling quantitative skills and mindsets for the full range of

majors, from those with moderate mathematics requirements to the most technical degrees in science and engineering. Our majors are well prepared for careers in industry and education and for further study in technical or professional areas.

2) **GRAND CHALLENGES:** "Tackling society's biggest challenges by enabling discoveries that will fundamentally shape the future." The department's faculty carry out world-class research in many areas of the mathematical sciences, ranging from curiosity-driven, disciplinary inquiry to applied and interdisciplinary research in the applications of mathematics as well as statistics and data science.
3) **ARIZONA ADVANTAGE:** "Advancing our land grant mission to drive social, cultural, and economic impact." Our outreach and teacher support activities through CRR, the Center for Recruitment and Retention of Mathematics Teachers, help address the severe shortage and rapid turnover of teachers of mathematics in Arizona, and our public lecture series and other outreach activities help inspire and inform the public about the importance and rapid rate of progress in the mathematical sciences.
4) **ARIZONA GLOBAL:** "Setting the standard for a global university in the digital age." Our international dual degree program in China extends the reach of the University, creates a pipeline for our graduate programs, and generates significant revenue for the department, college, and university.
5) **INSTITUTIONAL EXCELLENCE:** "Living our values and innovative culture to enable a high performing institution." The department is widely known as an efficient operation which makes excellent use of resources, is responsible and responsive to its many constituents, and generates both significant revenue and significant prestige for the university.

C. UNIT HISTORY

The Department of Mathematics dates back to the origins of the university in the late 19th century, and it has offered bachelor's and master's degrees since the late 1910's and graduate degrees since about 1960.

The late 1970's early 1980's saw serious attention paid to "entry-level" math (non-STEM service courses), with small sections. Also, the beginnings of serious outreach to schools eventually leading to PRISM and PRIME professional development for local teachers began in this period, and much of that work continues today.

The mid 1980's saw strong growth in research while maintaining instructional and outreach missions. Special research focus years brought visibility and excellent faculty candidates. Research funding soared. This period also saw major developments in instruction, including a professionalized cohort of entry-level faculty with multiyear contracts and a career progression as well as leadership in the Calculus Consortium which transformed the teaching of calculus nationally.

In 1990 the department received the TIAA-CREF Hesburgh Award for Excellence in Teaching and Learning. In 1997 the department was profiled in the AMS publication "Towards Excellence: Leading a Math Dept in the 21st Century" as an example of department in a public university combining a significant teaching obligation with excellence in research and impactful outreach. In 1997, the Southwest Center for Arithmetic Geometry was founded with a "Group Infrastructure Grant". Their "Arizona Winter School" is still active and funded today.

The 2000's brought major training grants (S-STEM, VIGRE twice) and increased research activity. Department ranked in mid-30's (top 10%) in USNEWS, NRC, etc. The Math Center won the AMS Award for an Exemplary Program in 2011.

The time around the previous review was somewhat turbulent with respect to departmental leadership, with five different heads in the period between 2013 and 2017. The current head was recruited with a mandate to preserve and build research strength in the face of several critical retirements and the damage done by the financial crisis. Much has been accomplished, both in renewing research strength and in putting the department on a sound financial footing, but great damage was also done by the pandemic and resulting management issues with the college and university, and much remains to be done.

C.1. Major Changes Since Last Review

- Taking into account faculty who will arrive in Fall 2024, the department has recruited 16 new faculty members since 2017, just short of balancing 17 retirements (16.5 FTE). See Section E For a more detailed analysis of faculty trends.
- The department has invested massively in its postdoctoral program, both in terms of salaries for fellows and in terms of leadership and faculty input. Starting in 2016, the College of Science devoted a $400,000 line item to the program, enough to fund roughly 8 fellows. The department has invested another roughly $600,000 per year to support fellows' salaries, we ensure that every postdoctoral fellow has a faculty mentor, and one of the associate heads is tasked with

developing and running the program. The latter is a highly non-trivial undertaking which involved developing a comprehensive suite of professional development activities and a robust program of observation, feedback, and mentoring in research, teaching, and service. See Section I2. for more details.

- Starting in 2017, the department offered new BS/BA degrees in Statistics and Data Science (SDS). These have proven to be popular with students, and we now have over 200 SDS majors. Some of these may have been Mathematics majors, while others were recruited from other fields. We are currently revising this degree to have more computing in the core and with several emphasis tracks including Comprehensive Statistics, Applied Statistics, Computer Science, and Biology. Other tracks are planned in the near future. See Section H for more details.
- Starting in 2021, we entered into a dual-degree arrangement with the Capital University of Economics and Business (CUEB) in Beijing. CUEB students take basic courses from Chinese faculty and advanced courses from UA faculty in person in Beijing. At the end of the four-year program, they earn degrees from both institutions, the UA degree being the SDS degree mentioned above. The first cohort included 72 students, and the most recent cohort included 115 students. At steady state, the program will enroll 120 students per year.
- The department continually reviews and revises its curriculum. Since the last review, we have introduced new courses and revised or eliminated others. See Section H.1.f for more details.
- CRR, the Center for Recruitment and Retention of Mathematics Teachers, has greatly expanded its operations, moving from a focus on Southern Arizona to providing services across the state.
- Starting in Spring 2018, the department revised its governance structure, adding new associate heads aligned with the various academic levels of our programs (entry level, STEM service, undergraduate majors, graduate programs, and postdoctoral fellows).
- The School of Mathematical Sciences (encompassing the Department as well as the Graduate Interdisciplinary programs in Applied Mathematics and in Statistic and Data Science) has rebooted its advisory board to focus on opportunities for students interested in careers outside academia. The board consists mostly of mid-career alumni and provides insight into industrial opportunities, mentoring, internship opportunities, and entrée into the companies and labs where they work.

C.2. Summary of Recommendations and Responses to Last APR

The 2015-16 APR site visit team made 36 recommendations across eight major categories. The most important recommendations and changes that resulted from the review were:

- "Create a strategic plan." The department commenced a strategic planning exercise for faculty hiring in 2018-19 which was unfortunately overtaken by events with the pandemic. A new effort commenced in 2023-24, and the results are discussed in Section L below.
- "Implement a mentoring/training program." Junior faculty meet with the head annually (and more often as needed) to get feedback on annual review and progress to tenure. They also each have an assigned faculty mentor. The department created a "Tools you can use" series of training sessions around hardware, software, data sets, teaching practices, policies, etc., to bring newcomers (and older faculty …) up to speed on tools of interest.

- "Encourage training grant submissions." Since the last review, departmental faculty have successfully competed for TRIPODS, RTG, and S-STEM projects. A large team also prepared a strong Institute Proposal (IMaSS---the Institute for Mathematics, Science, and Society) focused on discovering and solving fundamental problems from domain disciplines. Although the project was not funded, the connections built with other units on campus have proven to be valuable.
- "Increase startups and recruiting salary" and "take advantage of programs like SPFI." Increased startup support was explicitly part of the hiring package of the head recruited in 2017, and the department has made good use of the SPFI program, with three proposals, two funded, and one successful recruitment. In general, recruitment results in recent years have been excellent.
- "Focus on retention." This has been an issue for decades because the department routinely recruits and mentors strong junior faculty members, some of whom move on to other positions. During this review period, we have had one successful (and critically important) retention effort, and four cases where a tenure-track faculty member left. Significant efforts by our Climate and DEI committee to improve working conditions and atmosphere will support retention of members for all segments of our community.
- "Support graders." The department has started supporting grader positions for 300- and 400-level MATH and DATA courses with enrollment of at least 15 students. Up to 6 hours of grading per week may be allotted to each course section. Recruitment and assignment of graders is facilitated by a postdoctoral fellow as one of their service options. Graders should have previously taken the course they are grading for and received an A.
- "Identify faculty for awards." This has been a focus area, and has resulted in a University Distinguished Professor appointment, university-level teaching awards, a university-level mentoring award, and several Galileo Circle awards for faculty and staff.
- "Establish a Diversity Committee." Done, in the form of a "Climate, Diversity, Equity, and Inclusion" committee which has been very active in surveying our state and making recommendations for improvement.
- "Create paths for promotion for instructional faculty." We have a well-defined career path for career-track faculty (instructor-lecturer-senior lecturer-principal lecturer) and good progression through these ranks in recent years.
- "Plan for continuing the recruitment of underrepresented students after William Velez retires." The Math Center, under the capable leadership of Velez-mentee Jason Aubrey, continues to recruit and mentor students of all types into our majors.
- "Clarify oversight of outreach programs." A senior faculty member coordinates our outreach programs.
- Numerous recommendations of the shape "find money to support this good idea." The department has worked hard to develop streams of revenue that are independent of baseline support from the College of Science (including summer instruction, online instruction, and the dual degree program with CUEB), thereby achieving a certain level of autonomy with respect to non-salary expenditures. This effort has been very successful, generating about $2.39M (out of total expenditures of $17.12M). These revenues have supported many of the initiatives mentioned above or suggested by the previous review team, including postdocs, seminar and conference support, furniture, and equipment, etc. An overview discussion developed by an ad hoc "Resource Task Force" convened in Fall 2023 is available to the review team. The report is available at https://www.math.arizona.edu/files/APR2024/ResourceReport.pdf

D. OVERVIEW OF THE UNIT'S ACADEMIC QUALITY

D.1. Reputational and Outcome Indicators

- Our faculty have been awarded many significant internal recognitions: At the beginning of the review period, three were Regents' Professors (one has retired and one resigned); one University Distinguished Professor retired, and another was named; one faculty member holds an endowed chair; and five are Galileo Fellows, the College of Science's highest faculty distinction. Two career track faculty members are Galileo Circle Copernicus fellows, the highest distinction in that rank in the college. Professor Jennifer Wolfe was awarded major prizes for teaching from the department, the college, and the university, the latter being the Sherrill Prize for Creative Teaching. Numerous other faculty members have won College of Science or University awards for teaching, advising, and mentoring.
- Many faculty members have also been achieved major national distinctions: six are Fellows of the American Mathematical Society, one is a Fellow of the Society for Industrial and Applied Mathematics, two are Fellows of the American Statistical Association, two are elected members of the International Statistical Institute, two are Fellows of Optica, one is a Fellow of the American Educational Research Association, two are Fellows of the Institute of Mathematical Statistics, and one is a Fellow of the American Geophysical Union. Seven junior faculty have been awarded CAREER grants, and four were named Sloan Research Fellows. One was awarded a US Patent in 2022. Professor Marta Civil was given a lifetime achievement award from the National Council of Teachers of Mathematics. Professor Misha Chertkov was named a Fellow of the American Association for the Advancement of Science, the fourth of our faculty to be so named. Professor Deb Hughes Hallett won the 2022 American Mathematical Society Award for Impact on the Teaching and Learning of Mathematics.
- Fourteen of our faculty currently serve on the editorial boards of at least 27 journals.
- The research carried out in the department attracts large amounts of external funding. Annual expenditures average over $3.5M in the last six years, and recent large infrastructure grants include a Focused Research Group, a Research Training Group, a TRIPODS award, and a grant for Innovation in Graduate Education.
- In the HERD rankings of the National Science Foundation, the department is ranked 39th in federally funded research expenditures in 2022 (latest available) and 27th among public universities. Our graduate program is ranked 43rd by US News and 23rd among public universities.
- Our dynamic postdoctoral program has trained 68 postdocs since 2016. Many chose to continue in academia and currently hold tenure-track or equivalent positions at US or international institutions. 17 are currently in training. Accolades include 3 university-level outstanding postdoctoral awards, 1 honorable mention, 10 AMS-Simons travel awards, 2 NSF research grant awards, and 1 AOR award. Details are provided in Section I2.
- The PhD program graduates a higher percentage of domestic students and a higher percentage of underrepresented minorities than comparable institutions. See Section I for more details. Recognition for graduate students includes the following: an NSF Postdoctoral Fellowship award, two overall winners of College of Science TA/Mentor Award, a winner of the Peter W.

Likins Graduate Fellowship Award, A College of Science Linda, and Ken Robin Distinguished Graduate Fellowship.

- Our Undergraduate programs in Mathematics and Statistics & Data Science have shown outstanding resilience during the Pandemic years, producing an approximately constant 120 degrees per year during the APR period, despite an overall 10% decline in enrollments. Over 15% of these degrees are earned by Hispanic / Latinx students, a higher proportion than at comparable institutions. Awards for undergraduate students include: at least one NSF Graduate Fellowship per year, an Astronaut Foundation Scholarship in 2022, as well as several Outstanding Senior and Excellence in Research awards bestowed upon students graduating with one of our majors by the College of Science.
- Staff awards:
    - Spring 2023 Early Math Placement Outreach Provost Investment Fund Recipients, Tina Schuster, Tina Deemer, Michelle Woodward
    - 2023 Arizona Mathematics Leaders (AML) Leadership Award: Melissa Hosten
    - 2023 College of Science Staff Advisory Council Award: Nellie Rios
    - 2022 College of Science Distinguished Advising Award: Laurie Varecka
    - 2022 STAR Award: Hanh Do, Michelle Woodward, Tina Schuster
    - 2022 College of Science Staff Advisory Council Award: Brooke Valmont
    - 2020 Galileo Circle Copernicus Award: Tina Deemer
    - 2020 College of Science Staff Advisory Council Award: Michelle Ort
    - 2019 Team Award for Excellence by the UA Employee Recognition Committee: Center for Recruitment & Retention of Math Teachers Melissa Hosten, Rodrigo Gutierrez & Michael Perkins
    - 2019 College of Science Staff Advisory Council Award & “Best of the Best”: Aubrey Mouradian
    - 2019 STAR Awards: Melissa Hosten & Nellie Rios
    - 2018 College of Science Staff Advisory Council Award: Gus Kyriakakis
    - 2018 University of Arizona Team Award for Excellence nomination: Math Center (Nellie Rios, Michelle Ort, Laurie Varecka (& Jason Aubrey, faculty)
    - 2017 College of Science Staff Advisory Council Award: Chris Carbone

D.2. Comparison to Peer Institutions

There are few departments that share our characteristics of being i) a unified department including math, applied math, and statistics, ii) embedded in a land-grant, Carnegie R1, AAU-member university that is also a minority serving institution. To capture many of these elements, we selected the following seven peers (all departments of mathematics):

University of Florida (ABOR peer)

University of Wisconsin (ABOR peer)

University of Illinois Urbana-Champaign (ABOR peer)

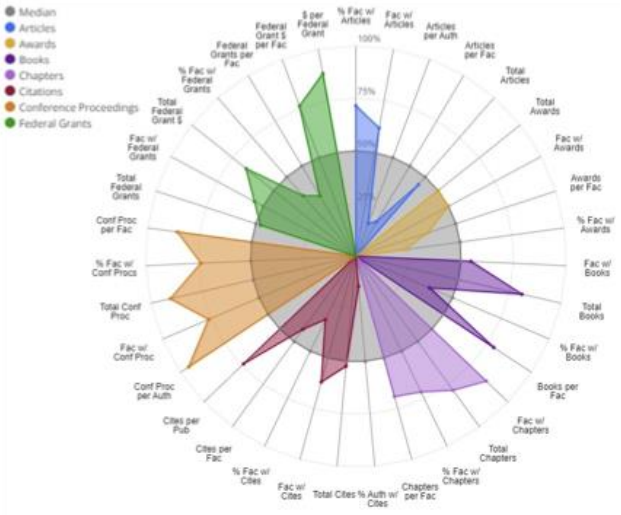
Ohio State University (ABOR peer)

University of California at Riverside (Hispanic Serving Institution)

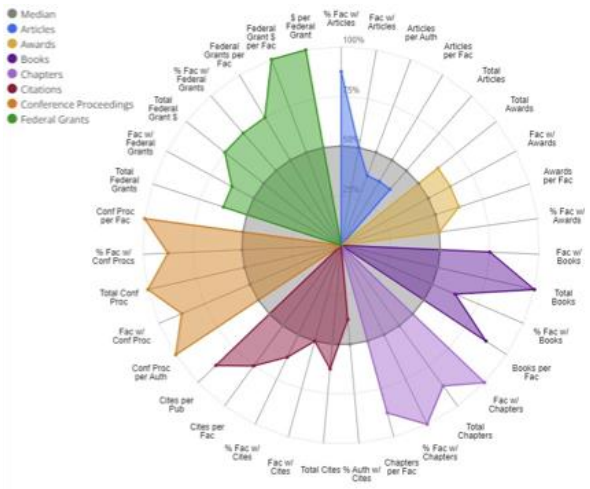
University of Massachusetts at Amherst (combined Mathematics and Statistics)

University of New Mexico (both Hispanic Serving and combined Mathematics and Statistics)

See below for the Academic Analytics radar chart for the full group of public AAU universities. It is perhaps useful to think about the four publication categories (articles, conference proceedings, book chapters, and books) collectively. In all four categories, we are generally above the 50th percentile, and often closer to the 75th. The metrics for articles are our weakest point, but this may be influenced by different publication cultures between math, applied math, and mathematics education. Conference proceedings and book chapters are the norm in the latter field, and much less common in core mathematics, thus our profile may differ from a more traditional mathematics department. In both grants and citations, the total numbers are strong whereas the numbers per faculty member are weaker. This indicates widely varying performance among faculty members, with strong performers bringing up totals, and weaker performers reducing averages. Finally, in awards, totals are near the 50th percentile, and averages are much lower, again indicating differential performance, but also a need to work harder on nominating top faculty for external awards.



The second figure on the following page is the radar chart comparing Arizona Mathematics with the seven selected peers. Overall percentiles are high, but with many of the same differentials as with the broader comparison group.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E. FACULTY

E.1. Faculty Research

Our faculty does research on a wide variety of topics, ranging from curiosity-driven, fundamental mathematics to highly applied questions, and in areas ranging across the mathematical sciences broadly construed. We have traditionally divided these efforts into five major categories discussed below. In light of faculty turnover and new hires, this categorization is being reconsidered by the personnel committee as part of their development of a strategic hiring plan, also discussed below.

The major groups are presented on our web site as:

- Algebra/Geometry
  - Group Theory
  - Number Theory
  - Topology and Geometry
- Analysis
  - Analysis and its Applications
  - Dynamical Systems
  - Geometric Analysis
  - Mathematical Physics
- Applied Mathematics
  - Computational Science and Numerical Analysis
  - Fluids and Mechanics
  - Mathematical Biology
  - Nonlinear Waves
  - Optical Science
- Education
  - Mathematics Education Research, Teacher Preparation, and Outreach
  - Undergraduate Education
- Probability/Statistics
  - Probability
  - Statistics

A few remarks on these groups: “Number Theory” is concentrated in arithmetic geometry and has had several waves of regeneration over the years, with its reputation and attractiveness to faculty candidates sustained by the Arizona Winter School. “Topology and Geometry” includes algebraic geometry. “Group Theory” has suffered several faculty losses during the review period and needs reinforcement. There are large overlaps among the subgroups in “Analysis” and “Applied Mathematics.” Research in these areas has been a reputational mainstay of the department for at least 50 years and is closely associated with (but not contained in) work contributing to the GIDP in Applied Mathematics. In “Probability and Statistics,” the emphasis has shifted considerably over the last decade from a strong emphasis on probability to a more balanced division between the subfields. This is related to the introduction of a GIDP in Statistics and Data Science.

The following table illustrates the contributions of the faculty to the research groups. The number of marks in a box indicates the number of subgroups that a faculty member belongs to (as self-identified on our web site).

Name	Rank	Alg/Geo	Analysis	Applied	Math Ed	Prob/Stat
Aceves Sanchez, Pedro	Assistant		x	xx		
Henderson, Chris	Assistant		xx	xxx		
Hong, Serin	Assistant	x				
Izosimov,Anton	Assistant	x	xx	x		
Sanchez-Vizuet, Tonatiuh	Assistant		x	x		
Scharf, Henry	Assistant					x
Tang,Xueying	Assistant					x
Adiredja, Aditya	Associate				xx	
Brio,Moysey	Associate			xx		
Choi,Sunhi	Associate		x			
Fatkullin,Ibrahim	Associate		xx			
Haessig, Doug	Associate	x				
Hao,Ning	Associate					x
Imbert-Gérard, Lise-Marie	Associate			x		
Joshi,Kirti N	Associate	x				
Keller, Christoph	Associate	x	x			
Mcgraw,Rebecca H	Associate				xx	
Niu,Yue	Associate					x
Pickrell,Douglas M	Associate	x	xx			
Stepanov,Mikhail	Associate			x		
Wolfe,Jennifer A	Associate				xx	
Xue, Hang	Associate	x				
Cais,Bryden R	Full	x				
Cherkis,Sergey	Full	x	xxx	xx		
Chertkov, Michael	Full			xxx		
Civil,Marta	Full				x	
Friedlander,Leonid	Full		xx			
Gabitov,Ildar R	Full			xx		
Glasner,Karl B	Full		x	xx		
Glickenstein,David A	Full	x	x			
Hu,Yi	Full	x				
Hughes Hallett,Deborah J	Full (.5FTE)				x	
Kennedy,Thomas G	Full		x			x
Kunyansky,Leonid	Full		x	x		

Lega,Joceline C	Full		x	xxx	x	
Lin,Kevin	Full		x	xx		
Lux,Klaus M	Full	x	x			
Maier,Robert S	Full (.5FTE)		xx			x
Miller, Laura	Full			xx		
Moloney, Jerome	Full (.5FTE)			xx		
Newell,Alan C	Full		x	xxx		
Piegorsch,Walter W	Full (.5FTE)					x
Rychlik,Marek R	Full			x		x
Sethuraman,Sunder	Full		xx			x
Shipman, Patrick	Full		x	x		
Sims,Robert J	Full		x			
Venkataramani,Shankar C	Full		xx	x		
Wang,Qiu-Dong	Full		x			
Watkins,Joseph C	Full			x		xx
Wehr,Jan	Full					x
Zhang,Hao (Helen)	Full					x
Anhalt, Cynthia	CSP				x	
Lozano, Guadalupe	CSP				xx	
Ulmer, Douglas	Head	xx				x

Another view on faculty research, perhaps more up to date, can be obtained by considering the list of weekly seminars:

Monday

- **Early Career Math Colloquium**
  When: 12:00 PM
  Location: Online
  Contact: Christian Parkinson, Rongchang Liu
- **Statistics & Data Science Colloquium**
  When: 2:30 PM
  Location: PAS 522
  Contact: Ning Hao
- **TRIPODS Seminar**
  When: TBA
  Location: PAS 522
  Contact: Melanie Bowman
- **Mathematics Instruction Colloquium**
  When: 4:00 PM
  Location: MATH 401; Online; https://arizona.zoom.us/j/84520935405 **Passcode:** teaching
  Contact: Taryn Laird and DeAnna McDonald

- **Data Research Training Group Seminar**
  When: 1:00 PM
  Location: MATH 402
  Contact: Kevin Lin and Laura Miller
- **Note:** Seminar will not be held every Monday. To receive seminar notifications, please contact Kevin or Laura.

Tuesday

- **Multi-lingual Optical Character Recognition Seminar**
  When: 11:00 AM
  Location: ENR2 S395
  Contact: Marek Rychlik
- **Analysis, Dynamics, and Applications Seminar**
  When: 12:30 PM
  Location: MATH 402/Online
  Contact: Keri Oligmueller
- **Algebra and Number Theory Seminar**
  When: 2:00 PM
  Location: ENR2 S395; Online; https://arizona.zoom.us/j/88176343452
  Contact: Pan Yan, Aparna Upadhyay
- **Quantitative Biology Colloquium**
  When: 4:00 PM
  Location: MATH 402
  Contact: Stacey L. LaBorde, Keri Oligmueller
- **Graduate Student Colloquium**
  When: 4:00 PM
  Location: MATH 501
  Contact: Sam Herring, Stephanie Marsh, Illia Hayes, Nicholas Juricic
- **UTA Seminar**
  When: 5:30 PM
  Location: Online; https://arizona.zoom.us/j/81430702856

  Contact: Aparna Upadhyay, Arvind Suresh

Wednesday

- **Uncertainty Quantification Group**
  When: TBA
  Location: Online; **https://math.arizona.edu/~klin/zuq**
  Contact: Kevin Lin
- **Hamiltonian Systems**
  When: 9:00 AM
  Location: Online
  Contact: Anton Izosimov

- **Mathematics Education Research Seminar**
  When: 12:00 PM
  Location: MTL 120
  Contact: Adi Adiredja
- **Mathematical Physics and Probability Seminar**
  When: 3:00 PM
  Location: MATH 402; Online
  Contact: Ibrahim Fatkullin, Darlayne Addabbo, Sunder Sethuraman
- **Algebraic Geometry Seminar**
  When: 2:00 PM
  Location: MATH 501; Online
  Contact: Yi Hu. Zhengning Hu. Debaditya Raychaudhury
- **Program in Applied Mathematics Brown Bag Seminar**
  When: 1:00 PM
  Location: MATH 402/Online
  Contact: Keri Oligmueller

Thursday

- **Modeling, Computation, Nonlinearity, Randomness, and Waves Seminar**
  When: 12:30 PM
  Location: MATH 402/Online
  Contact: Keri Oligmueller
- **Math Circle**
  When: TBA
  Location: Online
  Contact: **math-circle@math.arizona.edu**
- **Mathematics Colloquium**
  When: 4:00 PM
  Location: MATH 501
  Contact: Patrick Shipman; Serin Hong

Friday

- **Applied Mathematics Colloquium**
  When: 3:30 PM
  Location: MATH 501
  Contact: Keri Oligmueller

NOTE: See Section D for indicators of the prestige attached to the faculty's contributions.

E.2. Grants

Number of proposals submitted during selected fiscal years:

Proposal Status	2017	2018	2019	2020	2021	2022	2023
Funded	22	32	27	20	24	15	12
Pending						4	20
Not Funded	46	49	54	42	31	32	13
Total	**68**	**81**	**81**	**62**	**55**	**51**	**45**

Note that although the number of proposals declined over the review period, the number of awards and total expenditures increased (see following tables). This may be explained by the fact that faculty are pursuing larger group and infrastructure awards such as RTG, TRIPODS, and Institute proposals.

Number of root awards active during each selected fiscal year:

2017	2018	2019	2020	2021	2022	2023
70	70	84	92	91	85	87

Five Year Trend by Sponsor Type: Award Obligated Amounts:

Sponsor	2019	2020	2021	2022	2023
Federal	$2,582,228	$4,259,426	$1,686,735	$2,375,907	$2,631,752
Foreign	$4,000				
Government	$480,454	$325,475	$566,338	$863,941	$1,230,933
Industry	$82,880		$60,000		$23,157
Non-Profit	$84,000	$342,958	$536,527	$94,751	$126,425
Total	**$3,233,562**	**$4,927,859**	**$2,849,599**	**$3,334,599**	**$4,012,267**

List of Awards detail by award, PI, and Co-PI (FY2017-Jan. 2024) can be found at https://www.math.arizona.edu/files/APR2024/Awards.xlsx

E.3. Professional Leadership

We list service of our faculty on editorial boards, major advisory boards, and leadership in national or international organizations. In the interest of brevity, we do not list the very large number of grant panels, conference organization committees, external thesis committees, and external department evaluation committees. The scope of such service can be gleaned from the long-form CVs of faculty posted on their web sites.

Editorial boards:

"Avances de Investigación en Educación Matemática", Civil, 2020 -- 2022

"Educational Studies in Mathematics", Civil, 2017 --

"Environmetrics", Piegorsch, 2010 -- 2019

"Geometric Flows", Glickenstein, 2014 -- 2020

"Inverse problems", Kunyansky, 2018 --

"Investigations in Mathematics Learning", Civil, 2021 -- 2023

"Journal de Théorie des Nombres de Bordeaux", Ulmer, 2014 --

"Journal for the Study of Education and Development", Civil, 2017 -- 2019

"Journal of the American Statistical Association ", Hao, 2023 --

"Journal of the American Statistical Association", Niu, 2019 --

"Journal of Computational Dynamics", Lin, 2012 --

"Journal of Mathematical Physics", Sims, 2017 --

"Journal of Theoretical Probability", Sethuraman, 2022 --

"Journal of Urban Mathematics Education", Civil, 2019 --

"Mathematics Teaching in the Middle School Journal, Informing Practice Department", Wolfe, 2015 -- 2018

"Mathematics Teacher: Learning and Teaching PK-12 Journal, Ear to the Ground Department", Wolfe, 2019-2021

"Rocky Mountain Journal of Mathematics", Sethuraman, 2015 -- 2019

"SIAM Journal on Applied Dynamical Systems", Lin, 2021 --

"Stat", Hao, 2019 --

"StatsRef: Statistics Reference Online", Piegorsch, 2014 --

"Teaching and Learning in Higher Education", Lozano, 2020 -- 2023

"Teaching for Excellence and Equity in Mathematics", Civil, 2017 – 2023

Advisory boards:

AAAS Council Delegate, representing Section A (Mathematics), Lega, 2019 –- 2022

American Statistical Association, Arizona Chapter, Hao, 2022 -- 2023

ISC/IMU/IUPAC group on "A Global Approach to the Gender Gap In Mathematics and the Natural Sciences", Lozano, 2017--2019

Microbiology and Infectious Diseases B Research Committee (MID-B), National Institute of Allergy and Infectious Diseases (NIAID), Lega, 2020 – 2024

National Council of Teachers of Mathematics (NCTM) Task Force Committee for the Association of Mathematics Teacher Educators (AMTE) Mathematics Teacher Preparation Standards, Wolfe, 2016

NSF Division of Research on Learning Committee of Visitors, Civil, 2019

Public Broadcasting Service (PBS) Science Series NOVA Episode 4506: “Prediction By The Numbers” Science Advisor, Piergorsch, 2018

Physica D: Nonlinear Phenomena, Lega, 2018 --

SIAM Activity Group on Dynamical Systems, Lega, 2018 -- 2019

Western Regional Noyce Network, Anhalt, 2022-2025

Leadership:

Treasurer and Trustee, American Mathematical Society, Ulmer, 2021 --

Treasurer, Rocky Mountain Mathematics Consortium, Sethuraman, 2019 -- 2023.

Trustee, TERC (Technical Education Research Centers), Civil, 2015 -- 2020

Vice President, TODOS: Mathematics for ALL, Civil, 2015 -- 2018

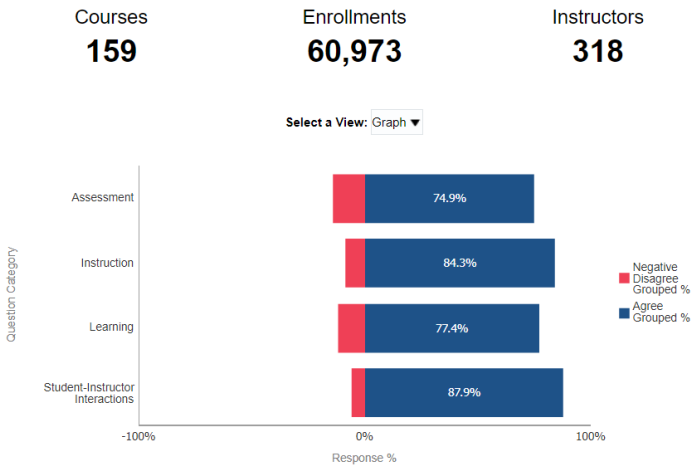
E.4. Teaching

Tenure track faculty who are research active have a 40% workload assignment to teaching, which amounts to nine units per year (normally two courses in the fall and one in the spring). Some tenure track faculty have different workload distributions reflecting major service assignments (lower teaching) or lower research contributions (higher teaching).

Instructors have a 90% workload assignment in teaching, which amounts to 18 units per year (normally 3 courses per semester). Lecturers have varying assignments ranging from 90% teaching and 10% service to 70% teaching and 30% service.

The department has a robust and wholistic program of mentoring for and review of teaching. All junior faculty are assigned teaching mentors. Mentors visit classes and provide feedback through an instrument developed by the university's Office of Instructional Assessment. For tenure track faculty, these reports, student surveys, and a review of syllabi, homework assignments, exams, etc., are integrated into a document (technically, a report to the head from an ad hoc committee) which is part of the promotion and/or tenure packet. For career track faculty, a similar process is organized by the Instructional Faculty Personnel Committee, and the output is used as a major factor in decisions to promote to Lecturer, Senior Lecturer, etc.

The following link gives a summary of Student Course Survey (SCS) data from 2019 to 2023. Prior to 2019, students completed Teacher and Course Evaluations (TCEs), but that data is no longer available. The following graph and table are a summary of this information. More details can be found at https://www.math.arizona.edu/files/APR2024/Studentsurvey.pdf .



Courses	Enrollments	Instructors
159	60,973	318

Select a View: Table

Question Category	Disagree Grouped %	Uncertain %	Agree Grouped %
Assessment	14.2%	10.8%	74.9%
Instruction	8.4%	7.4%	84.3%
Learning	11.7%	10.9%	77.4%
Student-Instructor Interactions	5.7%	6.4%	87.9%

Departmental faculty have received many college, university, and external awards for teaching and mentoring. We list just the awards in the last five years: Professor Jennifer Wolfe received the top university prize for teaching (the Sherrill award), the top College of Science award, and the top departmental award, all in two years! Professor Deb Hughes Hallett received the 2022 American Mathematical Society Award for Impact on the Teaching and Learning of Mathematics. Professor Nick Ercolani won the 2021 College of Science Distinguished Student Mentoring award, and advisor Laurie Varecka was awarded the 2021 College of Science Distinguished Advising award. In 2020, Professor Marta Civil won the Lifetime Achievement Award from NCTM, Professor Bruce Bayly won the College of Science Distinguished Career Teaching Award, Professor Adi Adiredja won the College of Science Early Career Teaching Award, and Professor Laura Miller was awarded Biosphere 2 Innovative Teaching Fellowship. In 2019, Senior Lecturer Donna Krawczyk won the College of Science Distinguished Career Teaching Award, and Professor Joceline Lega won the university's inaugural Excellence in Postdoctoral Mentoring Award.

E.5. Recruiting

The tenure-track recruitment process is similar in outline to that at other large public flagships: The college authorizes a search, the department advertises on Mathjobs, the personnel committee selects interviewees, evaluates the interviews, and makes recommendations to the head who then negotiates the terms of an offer which is approved by the dean and provost. A large amount of input from the entire tenure-track faculty goes into the selection of interviewees and the evaluation of the interview. Traditionally, this department has not specified the fields of research in advance. The current head has encouraged a higher level of planning around fields of interest, and the results of a recent effort are discussed in Section L.

Significant effort has been put into broadening the applicant pool and into using programs like SPFI (the University's diversity hiring program) and spousal hiring, reducing bias in evaluation of candidates, and improving climate and retention efforts, all with the goal of increasing the diversity of our faculty and its capacity to serve a rapidly changing student body.

Recent tenure-track hires and P&T actions are summarized in the table below. Ranks are indicated by colors: full, associate, assistant. (For P&T actions, all successful, we report the final rank using color.)

	2017	2018	2019	2020	2021	2022	2023
Hire	Ulmer	Izosimov, Keller	Henderson, Tang, Chertkov	Sanchez-Vizuet, Imbert-Gerard, Miller	Haessig		Aceves, Hong, Scharf, Shipman
Retire		Bhattacharya, Flaschka, Velez		Conway, Madden	Bayly, Laetsch, Cushing, Zakharov	Indik, Ercolani	
Resign				Hall, Morzfeld, Gillette	Zhang	Levin	
P&T	Glickenstein, Niu	Gillette, N. Hao		Adiredja, Sims	Keller, Xue	Lin, Imbert-Gerard	(underway)

NOTE: For 2024, we will have 3 new recruits (assistants Medvedevsky and Cipolloni, and full professor Pollack) and one retirement (Piegorsch).

E.6. Salaries

Faculty compensation range broken down by academic rank:

		2017		2018		2019		2020		2021		2022		2023	
Academic Rank	Tenure Status	Institutional Base Salary MIN	Institutional Base Salary MAX	Institutional Base Salary MIN	Institutional Base Salary MAX	Institutional Base Salary MIN	Institutional Base Salary MAX	Institutional Base Salary MIN	Institutional Base Salary MAX	Institutional Base Salary MIN	Institutional Base Salary MAX	Institutional Base Salary MIN	Institutional Base Salary MAX	Institutional Base Salary MIN	Institutional Base Salary MAX
Professor	Non-Tenure Track									54,000	54,000			60,000	60,000
	Tenure Track	82,714	171,441	82,982	171,441	84,642	171,441	86,093	176,000	76,693	171,797	91,129	191,670	98,373	218,020
Associate Professor	Non-Tenure Track	68,500	68,500	68,500	68,500	69,870	69,870	82,158	82,158	69,834	69,834	82,980	82,980	91,673	91,673
	Tenure Track	64,797	115,022	64,797	115,022	64,797	115,022	64,797	115,022	68,855	101,900	81,777	121,081	88,416	130,910
Assistant Professor	Non-Tenure Track	37,080	66,755	40,000	50,000	44,000	60,000	44,000	60,000	44,000	70,000	47,000	70,700	60,743	72,468
	Tenure Track	80,000	81,000	80,000	85,000	80,000	85,050	83,200	89,303	74,800	88,603	87,616	90,811	94,334	99,314
Instructor	Non-Tenure Track	32,000	47,476	3,998	40,000	37,000	44,000	40,000	51,000	40,000	51,000	40,000	44,440	45,000	50,150
	Tenure Track	74,706	74,706	74,706	74,706	76,200	76,200	76,200	76,200	68,488	68,488				
Lecturer	Non-Tenure Track	37,080	61,897	37,000	64,897	42,000	64,897	40,000	64,897	40,000	58,407	42,420	65,546	49,125	76,971
No Academic Rank	Non-Tenure Track	30	47,476	30	47,500										
	Tenure Track	110,404	116,436	116,436	140,000	140,000	140,000	145,600	145,600						

Comparison data is not available for the small peer set identified in Section D, but we do have data from the American Mathematical Society collected as part of their annual survey. (Downloadable at https://www.ams.org/profession/data/annual-survey/2019Survey-FacultySalaries-Report.pdf). The relevant peer group for us is “public large” (defined as a department awarding an average of at least 7 PhD’s per year in 2010-2019). For 2019-2020 (latest available), the AMS reports:

AMS data

	Q1	median	Q3	Mean
Full Professor	**127,100**	**146,800**	**172,500**	**152,930**
Associate Professor	**97,700**	**108,700**	**118,500**	**108,074**
Assistant Professor	**92,800**	**97,800**	**104,600**	**97,884**
non-TT faculty	**56,000**	**62,100**	**70,100**	**66,173**

A cursory glance at the data shows that our salaries are generally below the median for peers. A recent College of Science study showed that in all ranks, our salaries were below the lowest quartile for our AAU peers in Mathematics.

We hope to make a study of career track salaries in the near future, but reliable data is very hard to come by.

E.7. Faculty Demographics

Faculty by Sex

Sex	2017	2018	2019	2020	2021	2022	2023
Female	30.10%	32.00%	31.00%	33.30%	33.00%	33.00%	35.20%
Male	69.90%	68.00%	69.00%	66.70%	67.00%	67.00%	64.80%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Faculty by Sex and IPEDS Race/Ethnicity

IPEDS Race/Ethnicity	2017	2018	2019	2020	2021	2022	2023
Asian	17.50%	17.00%	16.00%	14.70%	16.50%	16.00%	19.30%
Hispanic or Latinx	6.80%	8.00%	6.00%	9.80%	7.20%	7.40%	6.80%
International	3.90%	5.00%	7.00%	5.90%	9.30%	7.40%	5.70%
Not Reported	1.90%	2.00%	3.00%	2.90%	2.10%	2.10%	2.30%
Two or more races		1.00%	2.00%	1.00%	1.00%	1.10%	
White	69.90%	67.00%	66.00%	65.70%	63.90%	66.00%	65.90%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

E.8. Faculty CVs

Faculty CVs
https://www.math.arizona.edu/files/APR2024/CVs.pdf

F. UNIT ADMINISTRATION

F.1. Department Organization

Day-to-day administration is carried out by the head, a team of five associate heads (for entry level, STEM service, majors, graduate programs, and postdoctoral programs), a representative of the career-track faculty, and the chairs of the GIDPs in Applied Math and Statistics and Data Science. They are assisted by the staff team represented by senior staff members Tina Deemer (Director of Academic and Support Services), Hahn Do (Business Manager), Chris Carbone (Director of IT Services), and Ali Gaona (Head's admin).

Faculty set policy and provide input to recruitment and review processes through the following committees:

Graduate, Undergraduate, and Post-doctoral Committees,

Promotion and Tenure, Peer Review, and Instructional Faculty Personnel Committees,

Awards, Climate-DEI, and Planning Committees,

Colloquium, Library, Computer, and Human Subjects Committees,

and a few other minor committees. (This structure is currently being reviewed, see Section L). Many of these committees have career-track, post-doctoral, or graduate representation as appropriate.

A pdf org chart is available here: https://www.math.arizona.edu/files/APR2024/orgchart.pdf

Note that the GIDPs report to the Graduate College, not the College of Science, so their chairs, in their roles as GIDP chairs, do not report to the Head of the Department of Mathematics. Nevertheless, there is close coordination, and the department head is also Chair of the School of Mathematical Sciences which includes the department and the two GIDPs.

F.2. Employees by Appointment Type

All employees by ABOR classifications – Headcount

	Fall 2019	Fall 2020	Fall 2021	Fall 2022	Fall 2023	Current (Jan. 2024)
Headcount Total	**351**	**352**	**359**	**366**	**433**	**402**
Administrators	1	1	1	1	1	1
Faculty	103	98	95	89	101	103
Graduate Assistant/Associate	100	84	96	99	102	91
Post-Doc	21	19	19	18	17	17
Staff	34	31	29	34	40	38
Students	92	119	119	125	172	152

Note that the graduate headcount here is of graduate *employees* and therefore includes students in the GIDPs in Applied Math and Statistics who are employed by the department as GTAs.

All employees by ABOR classifications – FTE

	Fall 2019	Fall 2020	Fall 2021	Fall 2022	Fall 2023	Current (Jan. 2024)
FTE Grand Total	**223.34**	**213.92**	**207.27**	**210.29**	**239.88**	**229.96**
Administrators	1.00	1.00	1.00	1.00	1.00	1.00
Faculty	97.70	93.70	91.32	84.83	97.78	100.27
Graduate Assistant/Associate	43.57	37.00	39.75	43.16	44.50	39.25
Post-Doc	20.50	18.50	19.00	18.00	17.00	16.65
Staff	28.34	26.39	25.38	29.52	35.10	33.60
Students	32.23	37.32	30.82	33.79	44.50	39.19

F.3. Staff by Gender and Race/Ethnicity

All Staff by IPEDS Race / Ethnicity

	Fall 2019	Fall 2020	Fall 2021	Fall 2022	Fall 2023	Current
American Indian or Alaska Native	0.6%	0.6%	0.3%	0.3%	0.2%	0.2%
Asian	6.8%	8.2%	10.3%	11.2%	10.6%	10.9%
Black or African American	0.9%	0.6%		1.1%	2.3%	1.7%
Hispanic or Latinx	26.5%	22.4%	16.7%	16.9%	16.6%	17.4%
International	13.7%	13.1%	18.7%	17.5%	17.8%	15.9%
Not Reported	2.3%	2.0%	1.4%	1.4%	1.2%	1.2%
Two or more races	2.8%	4.0%	2.2%	2.5%	1.4%	1.7%
White	46.4%	49.1%	50.4%	49.2%	49.9%	50.7%

F.4. Adequacy of Staff Support and Plans to Improve Efficiency

Our staff is incredibly hard-working and highly skilled. They manage a sizable workload, but most are flexible enough to fill in when we have occasional gaps. Generally, we have enough staff to support the department's missions, with a few notable exceptions.

1. Our academic advisor recently resigned, and we have been unable to repost the position due to the hiring freeze. We have submitted a request to hire and are awaiting approval, which we expect will happen.
2. We need additional administrative support for the ever-expanding Math 100 course. The resignation of an administrative support professional in December made us once again vulnerable to the hiring freeze. Because of the need to prioritize hiring, we have not made a request to hire in this position. This means that other staff have been tasked with additional duties. We have managed this, but it is likely to become untenable starting in August, when Math 100 enrollment is at its peak.
3. We have struggled to improve efficiency in various processes due to a shortage of FTE in database programming. We currently have one .5 FTE developer, and he is often pulled into many projects, including our website redesign. We need another 1.0 FTE developer to enable us to complete urgent database projects.

G. UNIT RESOURCES

G.1. Budget

To a first approximation, the personnel part of our budget (faculty, staff, graduate students) operates on an incremental model, and the operational part (travel, seminars and conferences, postdocs, computers, and furniture, etc.) operates on an activity-based model. The department has been very entrepreneurial in developing new courses, degrees, and programs (summer and online courses, an international dual degree, and professional master's degrees) which generate all the revenue we have for operations. (The committee is invited to read the report of an ad hoc "Resource Task Force" which explains how the university's financial model works for the department. It shows that we have a roughly balanced budget and a small cash reserve. https://www.math.arizona.edu/files/APR2024/ResourceReport.pdf) The financial crisis of 2023-24 threatens to change or eliminate this model, so our operations may be in danger. Without a commitment to continue passing through a significant fraction of the revenue generated by ancillary activities (summer, online, international, professional master's degrees), we will not be able to continue these activities.

G.2. Faculty

The department's research faculty is clearly too small for the range and intensity of activities that we are asked to carry out. The current head had an understanding with the previous dean that the appropriate size of our tenure-track faculty is 60 FTE, and there was a commitment to growing back to that size (from 53 FTE in Fall 2017). In the intervening years, we experienced Covid and the resulting financial damage, leadership turnover, and many retirements and resignations. Luckily, we also experienced strong support from College of Science leadership and the SPFI (diversity hiring) program, and we project a tenure-track faculty of 52.5 FTE in Fall 2024. Without a strong commitment to replenish our faculty, we will have no choice but to scale back activities, thereby reducing revenue and prestige to the college and university.

G.3. Graduate Students and Postdocs

The department has about 50 graduate students in the Mathematics program, a number which is arguably too small for an R1 department with 50 to 60 tenure-track faculty. Stipends are low but increasing, and recruitment is challenging. Faculty with the appropriate research interests also have access to graduate students from the GIDPs in Applied Math and Statistics, partially alleviating the lack of students in Math but also imposing costs on the department's TA budget. (About 40% of our TA expenses are devoted to the two GIDPs.) Also, about 20% of our TA budget comes from activity-based operations revenue (see the budget discussion below), and this model is under threat in the current financial crisis.

The department also has about 20 post-doctoral scholars in residence, with a robust program of support for research, teaching, and professional development. (See Section I.5. for full details.) Only 8 of these positions are funded from the standing College of Science budget, and the rest come from operational revenues, so the program is not as stable as it should be.

G.4. Staff

The department has a small but extremely hard-working and efficient staff of about 34 FTE, supervised by Tina Deemer, our Director of Academic and Support Service, and organized into the following units:

The academic "front office" (Math 108) is the student-facing office which handles inquiries about courses and scheduling, placement, and transfer credit. They also support the faculty's instructional needs related to copying, scanning, etc. There are three admins "on the frontlines" and four other staff members providing support in the background.

The business office handles HR and business functions such as payroll, purchasing, travel reimbursements, pre- and post-award grant support, visas, and employment documentation. This group includes one manager, three accountants, and a program coordinator.

The IT group provides hardware and software support for all instructional and research needs. There is one manager, one developer, one sys admin, and one IT support analyst.

The head's office provides day-to-day assistance for the head and associate heads, supports the annual review and promotion and tenure processes, and organizes events such as conferences and public lectures. There are three admins here.

The Math Center provides support for our undergraduate majors in Math and in Statistics and Data Science. It is directed by Jason Aubrey, a Professor of Practice, and includes two professional advisors and a half-time administrative associate. (One of the advisors resigned recently and has not yet been replaced.)

The graduate office provides support for the graduate program in Mathematics and the Associate Head for Graduate Programs. It is staffed with one admin.

Several other staff members provide **academic support** related to Math 100, online courses, and instructional technology, as well as web design and **communications support.**

Finally, there are several other staff members who are employed through the department but either support other programs (such as the GIDP in Statistics) or are paid through grants and contracts (such as CRR).

G.5. Space

The department has adequate but dispersed space for offices, seminar, and meeting rooms, and even a few laboratories. Specifically, we have office spaces and seminar rooms in the Math tower (MATH) and in Energy and Natural Resources 2 (ENR2), classrooms in the Math Teaching Lab (MTL), office spaces in Physics and Atmospheric Sciences (PAS), and two laboratories in Biological Sciences West (BioW). Essentially all of the staff and administration is in MATH, the faculty are split between MATH and ENR2, and the graduate students are in ENR2. CRR and TRIPODS are housed in PAS. This fragmentation is a significant barrier to community-building and informal communications, but there is little prospect of improvement on the horizon.

H. UNDERGRADUATE STUDENTS, DEGREE PROGRAMS, AND OUTCOMES

H.1. Description of Undergraduate Degree Programs

The Department of Mathematics currently offers the following undergraduate degrees and minors:

- Bachelor of Science (B.S.) and Bachelor of Arts (B.A) degrees in Mathematics, with seven emphases/tracks to choose from
- Bachelor of Science (B.S.) and Bachelor of Arts (B.A) degrees in Statistics and Data Science
- Minor in Mathematics
- Minor in Statistics & Data Science
- Minor in Mathematics Teaching

All programs are available on Main campus; see changes section (H.1.f below) for notes on other availability added.

The Statistics and Data Science (SDS) degrees are comparatively new, having been created during the period covered by this Academic Program Review, and the first cohorts were enrolled in Fall 2018. These degrees will be summarized in 1.b. below.

H.1.a. B.A. and B.S. Degrees in Mathematics

These degrees each have CIP code 27.0101 (Mathematics General). Each degree requires a set of core courses (see handbook p.18 for details) and completion of coursework in one of seven emphases (listed below). The two degrees differ only in the second language requirement and the science/application course requirements. For the B.A., students must have fourth semester proficiency in a second language. The B.A. degree is not considered science-intensive, as students need to complete only the science coursework requirement as specified by the University General Education Program. The B.S. degree requires students to have second semester proficiency in a second language, but it is science intensive, requiring two-semesters of laboratory science, and for emphasis options other than Math Education, also requires additional units or “application courses” having at least a calculus 1 prerequisite; the total number of such units required changed from 6 to 3 in 2022 when the university’s general education program changed.

Students completing a major in mathematics are expected to:

- Apply computational methods; Math majors should be able to apply computational methods and mathematical concepts to analyze scientific problems.
- Apply mathematical models to current problems; Math majors should be able to critically evaluate and extend selected mathematical models in the current scientific literature.
- Create valid proofs; Students should be able to identify an appropriate proof strategy and almost always be able to create a correct proof using multiple strategies as appropriate.
- Define Terms Precisely; Precision is essential in mathematics, and a crucial skill for math majors is to learn to define mathematical terms precisely.

- Effective communication of results; Math majors should be able to effectively communicate results to non-specialized audiences in written and verbal form.
- Recognize valid arguments; Logical rigor is a critical component of mathematical argumentation. We expect math majors to develop the ability to recognize when arguments are valid and identify logical gaps and flaws.

Math majors must choose one of seven emphasis tracks in which to complete their degree:

1. **Applied Mathematics emphasis**: This emphasis is for students who intend to enter the job market upon graduation but may also be appropriate for students who plan to go on to graduate school in a field of science or engineering.
2. **Comprehensive emphasis**: This emphasis prepares students for graduate study in mathematics, applied mathematics, or most other scientific fields.
3. **Probability and Statistics emphasis**: This emphasis is for students considering a career as an actuary or statistician, as well as for students wanting to attend graduate school in statistics.
4. **Mathematics Education emphasis**: This emphasis prepares students for teaching mathematics at the secondary school level with professional licensure from the Arizona Department of Education. The emphasis has three main components: a set of courses in mathematics, a set of courses in teaching and learning mathematics in secondary schools, and a set of courses in general education from the College of Education.
5. **Computer Science emphasis**: This emphasis is for students interested in applications of computers to mathematical problems, including math majors who plan to attend graduate school in computer science.
6. **Economics or Business emphasis**: This emphasis is for students with a particular interest in business applications of mathematics, especially those preparing for graduate school in economics or finance.
7. **Life Sciences emphasis**: This emphasis is for students considering a career in medicine, as well as for students wanting to attend graduate school in the biological sciences.

More detailed information about the options can be found in the handbook:

https://www.math.arizona.edu/files/APR2024/uhandbook.pdf

Note that the mathematics education option was relocated from the College of Education in 2003 and has remained an option in the mathematics major program. In the past, a unit in the College of Science offered a degree which included certification for secondary science teachers, but the degree was phased out due to lack of funding support from the college and at the university level. Currently, the mathematics department is the only department in the College of Science that offers a professional degree for students who plan on pursuing teaching at the secondary level.

The Conference Board of the Mathematical Sciences (CBMS) made a national recommendation in *The Mathematical Education of Teachers (MET) Reports I and II* (2001 & 2012 respectively) for mathematicians to play a larger role in the mathematical preparation of future teachers in parallel to pedagogy methods courses taught by mathematics education faculty, and general education courses taught by general education faculty. As a response to the call, our mathematics department was one of the first departments in the nation to establish a secondary mathematics teacher preparation program as a collaborative effort between the department of mathematics and the College of Education. The

program includes 76+ hours of field practicum internships plus a full-time capstone Student Teaching field practicum internship semester. Students graduate with a strong background in culturally relevant and culturally affirming teaching strategies in secondary mathematics. Students in the program earn their degrees from the mathematics department, and at the same time, become eligible for secondary mathematics certification in the state of Arizona and other states. As such, the Secondary Mathematics Education Program holds accreditation from the Arizona Department of Education, which is renewable every seven years with its most recent accreditation renewal in 2023.

H.1.b. B.A. and B.S. Degrees in Statistics and Data Science (SDS)

Since Fall 2018, the Mathematics Department has offered both a B.A. and a B.S. degree in Statistics and Data Science. The CIP code for these degrees is currently 27.0503 (Mathematics and Statistics); however, in Fall 2023 we submitted a request to change the CIP code to 30.7001 (Data Science, General), a designation which was unavailable when the degrees were initiated in 2018 and which better reflects the content and goals of these degree programs. The differences between the B.A. and B.S. in SDS are identical to those between the B.A. and B.S. in mathematics, as described in H.1.a. above.

Students completing a major in Statistics and Data Science are expected to:

- Be able to define mathematical and statistical terms precisely.
- Critically evaluate and extend statistical models drawn from current scientific literature.
- Effectively communicate their results.
- Produce effective analyses from data using a variety of computational, mathematical, and statistical approaches.
- Collect, organize, and visualize data for exploration, analysis, and communication.
- Identify data science tasks, be able to formulate and choose appropriate models and analytical tools to solve data science tasks.
- Effectively use one or more professional statistical and data analytics software package.
- Identify and analyze social, legal, and ethical issues in data science.

In Spring 2023, a committee was formed at the request of the Dean of the College of Science to significantly broaden the reach and appeal of the SDS major, and more fully realize the fundamentally interdisciplinary nature of Data Science by:

- Changing the name of the degree to “Data Science”
- Organizing the degree around a set of “core” courses, including a new course (DATA 201) designed specifically as an introduction to Data Science for College of Science students.
- Adding emphasis areas with coursework in other departments of the College of Science.
- Creating pathways through the degree to better more diverse student populations and ensure broad accessibility to students across the College of Science.

The committee finalized a proposal to implement these changes, which is currently working its way through the approval process. As such, we anticipate that our SDS degree(s) will be replaced by a new B.S. degree in Data Science, with several emphasis areas including Applied Statistics, Comprehensive Statistics (geared at graduate-school bound students), Computing, and Molecular & Cellular Biology.

These last two tracks are collaborations with their respective departments in the College of Science. We expect to develop and add more emphasis areas soon.

H.1.c. Minor in Mathematics

The Mathematics Minor has CIP code 27.0101 (Mathematics, General), and consists of (a minimum of) 18 total units of coursework, 6 of which must be upper division (courses numbered 300 and above), and at least 3 of which must be from UArizona coursework (rather than transfer credit). The Mathematics Minor is available online and is a popular option among students in several majors which already require a majority of the Minor coursework (e.g., Physics and Engineering), but our largest group of Mathematics minors currently comes from the Computer Science major.

H.1.d Minor in Statistics and Data Science

The Statistics and Data Science minor currently has CIP code 27.0503 (Mathematics and Statistics). As with our SDS majors, we are requesting a reclassification to CIP code 30.7001 (Data Science, General) to better reflect the content and goals of this minor. Like the Math minor, the SDS minor requires 18 units of total coursework, of which 6 must be upper division with 3 coming from UArizona coursework and is available online. It is worth noting that the core of the proposed new degree in Data Science described in H.1.b above is nearly identical to the SDS minor, and many students in the College of Science are in effect cobbling together their own degree programs in Data Science by combining our SDS minor with a major in another discipline. We anticipate that the proposed new degree in Data Science described in H.1.b. will better serve these students, while simultaneously providing a broader and deeper educational experience in Data Science.

H.1.e Minor in Mathematics (Teaching)

We discovered in the APR process that this minor is still technically owned by the College of Education, but since we own the courses involved, determine the curriculum, and provide advising for it, we are working with the College of Education to transfer ownership to us. This seems to have been an oversight when the Math Education major transferred over from the College of Education.

The Minor in Mathematics (Teaching) has CIP code 13.1311 (Mathematics Teacher Education) and consists of (a minimum of) 18 total units of coursework, 10 of which must be upper division (courses numbered 300 and above), and at least 3 of which must be from UArizona coursework (rather than transfer credit). Prior to 2022, this minor was only available to students enrolled in secondary education teaching majors, but we expanded to allow more students to enroll in the Mathematics Teaching Minor by allowing students in all other majors, including the mathematics major, to enroll in the Mathematics Teaching Minor. This minor provides opportunities for students who may be considering becoming secondary mathematics teachers beyond the BA/BS degrees. This minor requires 10-11 units in mathematics courses and 7 units in mathematics education courses that also include 46 hours of field practicum internships.

H.1.f Summary of Changes to Degree Programs and Offerings During the APR Period

- Fall 2017: The General/Applied emphasis of the math major (usually referred to administratively simply as General) was renamed "Applied."
- Fall 2018: A new major (BA & BS degrees) and minor in Statistics & Data Science (SDS) were added. The first degrees were awarded in Spring 2020.
- Fall 2019: UA South (a regional campus of UArizona located in Sierra Vista, Arizona) paused their math major offering due to lack of faculty resources and low enrollment. We are unsure when or if that campus (now known as College of Applied Science and Technology) will offer a mathematics major again. Enrollment in the major there was extremely small (usually no more than 3 students per year).
- Spring 2022: Online campuses for the Math minor (MATHMINU) and the Statistics and Data Science minor (STATDSMINU) were added.
- Fall 2022: The Math Teaching minor (MAEDMINU) was opened to all students, irrespective of their major. This minor was originally designed for--and restricted to--students who were already in a major program that led to certification to teach at secondary level in some subject area, with the idea that the minor would provide additional content, possibly leading to additional certification. However, these other secondary education programs were cut, leaving no audience for our Math Teaching minor. To compensate for this, all restrictions on the Math Teaching minor were lifted. We inform students selecting this minor that they need to complete a certification program (this minor is not sufficient to fulfill state certification requirements).
- Spring 2023: Global Direct campus for the Math minor (MATHMINU) and Statistics and Data Sciences minor (STATDSMINU) were added.
- Spring 2023: Our partnership to offer our Statistics and Data Science BS degree to students at Capital University of Economics and Business (CUEB) in Beijing, China, officially began. The first cohort of students began taking classes, initially as non-degree seeking in Spring 2023; they are degree-seeking students as of Fall 2023. We have designed six new courses to be taught at CUEB:
    - DATA 366 Multvariate Statistics
    - DATA 370 Sampling
    - DATA 460 Nonparametric Statistics
    - DATA 461 Time Series
    - DATA 472 Natural Language Processing. (This course is cross listed with an existing course, LING 472. However, our CUEB offering will be substantially different from the UA campus linguistics offering to match the needs of our students.)
    - DATA 476 Bayesian Statistics
- Several other new courses have been created for the Statistics and Data Science BA and BS major and minor
    - DATA 367 Statistical Methods in Sport Analytics
    - DATA 375 Introduction to Statistical Computing
    - DATA 412 Linear Algebra for Data Science
    - DATA 462 Financial Math
    - DATA 467 Introduction to Applied Regression and Generalized Linear Models
    - Data 498A Capstone for Statistics and Data Science

- New course for Mathematics BA and BS major and minor
    - MATH 481 Mathematical Modeling of Fluid Flow Through and Around Organs and Organisms

H.2. Enrollment Trends for Undergraduate Degree Programs

The tables below show enrollment trends in each undergraduate degree program over the APR period. Note that any student with a double major must identify one of their majors as "Primary," and the other as "Secondary," though the distinction is largely administrative, with many students not appreciating any distinction in the status of their majors. During the APR period, nearly 30% (on average) of students majoring in Mathematics or Statistics and Data Science were also majoring in another subject; as such, data that counts students by Primary majors only fails to account for many of our majors. The data below is University census data, including **both** Primary and Secondary majors.

Our population of majors and minors is somewhat fluid: students starting with a minor in math or SDS often end up declaring the major – and vice versa. The tables below provide enrollment numbers for our programs:

Major	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
Mathematics	576	590	550	450	391	355	334
Statistics and Data Science			50	123	183	192	201
Major Grand Total	576	590	600	573	574	547	535

^ university census data (includes both primary and secondary majors)

Math Major Emphasis	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
Applied (formerly General)	138	134	147	119	104	99	84
Comprehensive	62	52	57	52	56	46	44
Computer Science	79	73	71	66	45	44	38
Economics and Business	39	33	27	16	20	18	16
Education	33	36	26	26	37	46	46
Life Sciences	13	15	11	6	4	5	5
Probability and Statistics	89	72	60	28	22	23	24
Undecided/Undeclared	123	175	201	260	286	266	278
Grand Total	576	590	600	573	574	547	535

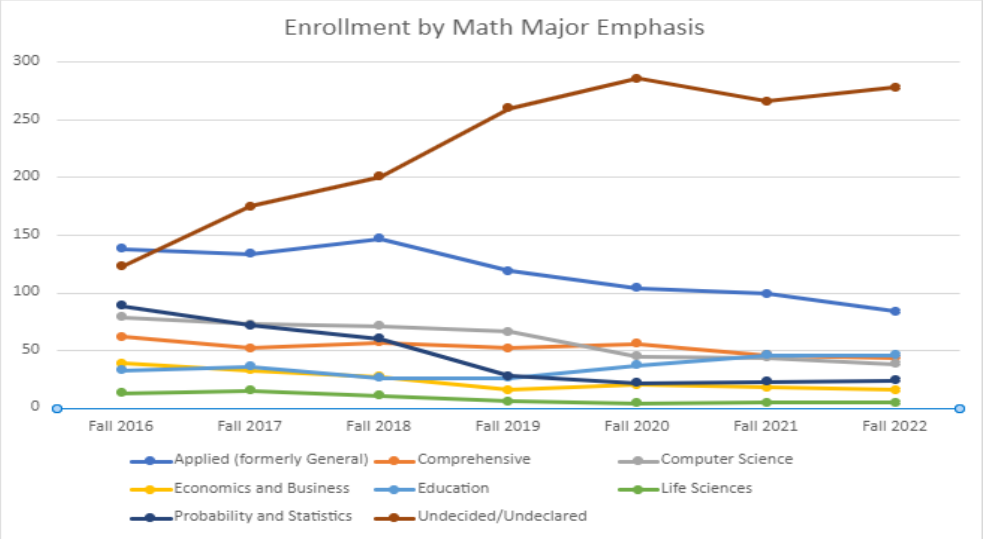
^ university census data (includes both primary and secondary majors)

Minor	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
Mathematics	622	672	684	621	674	566	495
Mathematics (Teaching)	1	1	0	0	0	1	3
Statistics and Data Science	0	0	30	65	107	113	114
Minor Grand Total	623	673	714	686	781	680	612

^university data from fall census

Note that we do not require completion of any courses (or minimum GPA) for admission to our majors or minors.

To provide a qualitative sense of enrollment changes within the Math major, the above data is visualized in the graph(s) below:



There are some obvious trends that merit discussion:

- While an emphasis within the math major is required to graduate, there is no prior hard deadline by which a declared major is required to select an emphasis. Furthermore, largely due to the COVID Pandemic, the format for the University's New Student Orientation changed permanently from in-person to online in Fall 2020. It is during this orientation that students who have declared the math major are guided through the different emphasis choices. We believe that students find digesting information in this format more challenging, and as such are less prepared to select an emphasis at the end of orientation than in years prior to 2020. Still, the bulk of the increase in majors with an undecided/ undeclared emphasis occurred prior to Fall 2020, and while the overall upward trend of mathematics majors with an undecided/ undeclared emphasis may be largely a reflection of a fundamental shift in student mindsets, it is important that we look for more advising opportunities to help students choose their emphasis and develop a clear sense of identity and direction within our mathematics major.
- Our Statistics and Data Science degree began in Fall 2018. The sharp decrease in the number of majors with the Probability & Statistics emphasis between Fall 2018 and Fall 2019 reflects the fact that many students enrolled in, or planning to enroll in, this emphasis in the math major instead selected the Statistics and Data Science major. At the same time, the addition of this new degree may have resulted in some confusion among students interested in studying statistics, thereby contributing to the sharp increase in the number of students with an undecided/ undeclared emphasis.
- There is an overall decline in the number of math majors during the APR period, beginning in Fall 2018. A primary driver of this trend is our Statistics and Data Science degree, which has seen a steady increase in student enrollments since its inception in Fall 2018. Nevertheless, the total

number of students across both majors has declined from highs of approximately 600 in Fall 2017 and 2018, to 535 in Fall 2022, a decrease of approximately 10%.

H.2.a. Discussion of Decrease in Majors' Enrollment Numbers

There are undoubtedly several factors leading to this decline of approximately 10% in enrollment numbers across our majors, but the following stand out:

1. The global Pandemic forced much of the instruction at UArizona online from mid Spring 2020, through Spring 2021. Nearly all instruction in mathematics was online during the first two semesters of this period, with most remaining online for Spring 2021. This format may have presented particularly acute challenges for students majoring in mathematics. Indeed, as noted before, many of our majors have 2 or more majors. These three consecutive semesters of largely online instruction in mathematics saw a marked decrease in the number of our students with 2 or more majors:

   Majors in Math and Statistics and Data Science with more than one major:

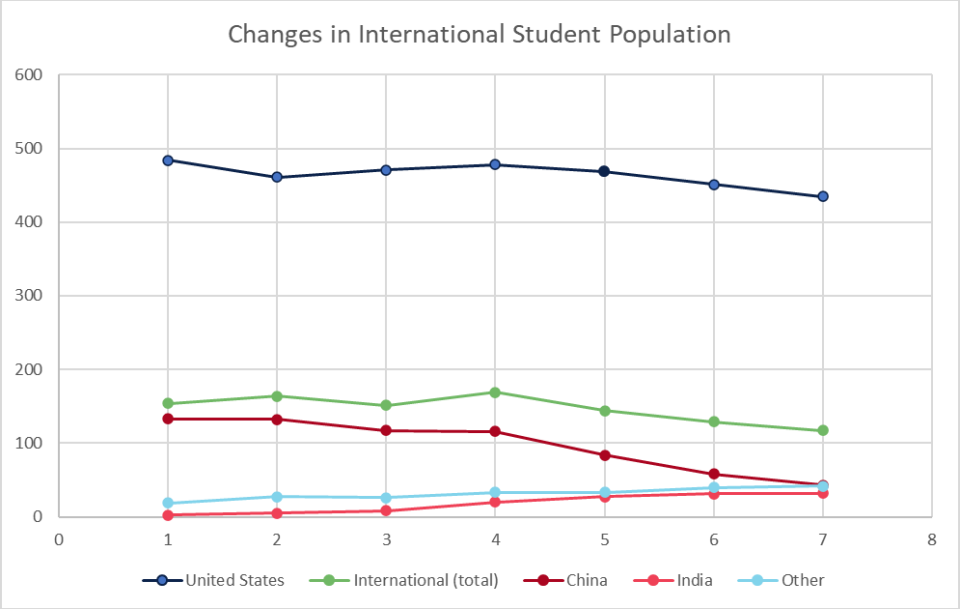
	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
2 majors	215	232	211	93	75	60	153
3 majors	24	21	33	15	13	11	16
4 majors	2	2	1	2			
5 majors	1	1	1				
6 majors				1	1		
Total with 2 or more	242	256	246	111	89	71	169

^ Source: departmental database, summer archive

Note the 56% drop in double majors from academic year 2018—2019 to 2019— 2020. It is very likely that this trend of students dropping all but one major was University-wide; given the popularity of Mathematics among double majors, this trend impacted our programs especially hard.

2. Mathematics is a popular major among international students, who have historically made up approximately 25% of our enrolled students. Prior to academic year 2018—2019, approximately 21% of these students were from China. Beginning in June 2018, the U.S. State Department reduced the validity of student visas for Chinese graduate students studying ``sensitive" subjects from 5 years to 1 year. On May 29, 2020, then President Trump issued further restrictions on Chinese student visas through Presidential Proclamation 10043, and by September 8, more than 1000 student visas had been revoked. Together with President Trump's trade war against China, these policies undoubtedly had a chilling effect on Chinese students considering studies in the U.S. Many of these visa restrictions have remained in place under the administration of President Biden, and Chinese student enrollments have continually declined over the APR period, from a high of 133 students in 2016—2017, to only 43 students in 2022—2023. At the

same time, our majors have seen an increase in students from India, as well as an increase in the diversity of the international student population: in 2016—2017, our international majors represented 13 countries (including China and India), while by 2021—2022, this number increased to 20. Beyond China and India, overall numbers are relatively small, with majors from any one country in the single digits. Despite these increases in overall diversity and majors from India, the precipitous decline in our Chinese student population has had an overall negative impact on the total number of majors, as the following tables and graphs (using data from our departmental database and combining our Math and SDS majors when both exist) make clear.



^ ^ Data from Math Center database

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
China	20.8%	21.1%	18.8%	17.9%	13.7%	10.0%	7.8%
India	0.3%	0.8%	1.3%	3.1%	4.4%	5.3%	5.8%
United States	75.9%	73.8%	75.7%	73.9%	76.5%	77.8%	78.8%
Other	3.0%	4.3%	4.2%	5.1%	5.4%	6.9%	7.6%

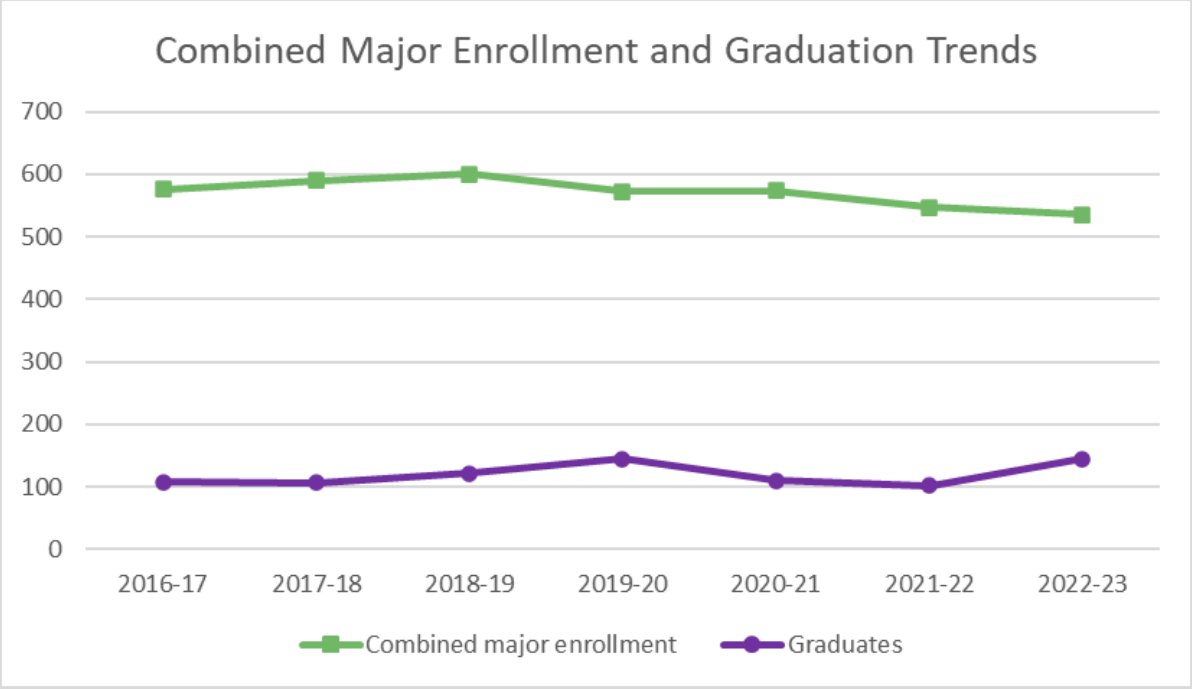
^ ^ Data from Math Center database

3. Since its inception in 2004, our Math Center (see section H.12.e) has spearheaded efforts to recruit students to our programs. Until his retirement at the end of Spring, 2017, these recruiting efforts were led primarily by then Director of the Math Center, Professor William "Bill" Velez. Our recruiting practices focus on encouraging students not already in our programs (who typically have another major already) to consider add a major or minor in Mathematics or Statistics and Data Science; in particular, we do not poach students from other majors. Professor Velez was well known and highly regarded as an especially effective and enthusiastic recruiter to our programs. While the Math Center has continued the tradition of robust recruitment, these efforts have perhaps been more targeted since Professor Velez's retirement, and there has been an overall decline in recruitment numbers since his departure. On the other hand, this more targeted approach to recruitment may be a leading contributor to an overall increase in

retention since 2017, modulo the rather severe and chaotic effects of the Pandemic; this will be discussed in more detail in section H.2.b below.

H.2.b. Enrollments and Retention

Although total enrollment numbers in our major programs have decreased overall during the APR period, the total number of graduates of our programs exhibits a generally stable—if not upward—trend outside of Fall 2020, which was most heavily impacted by the pandemic:



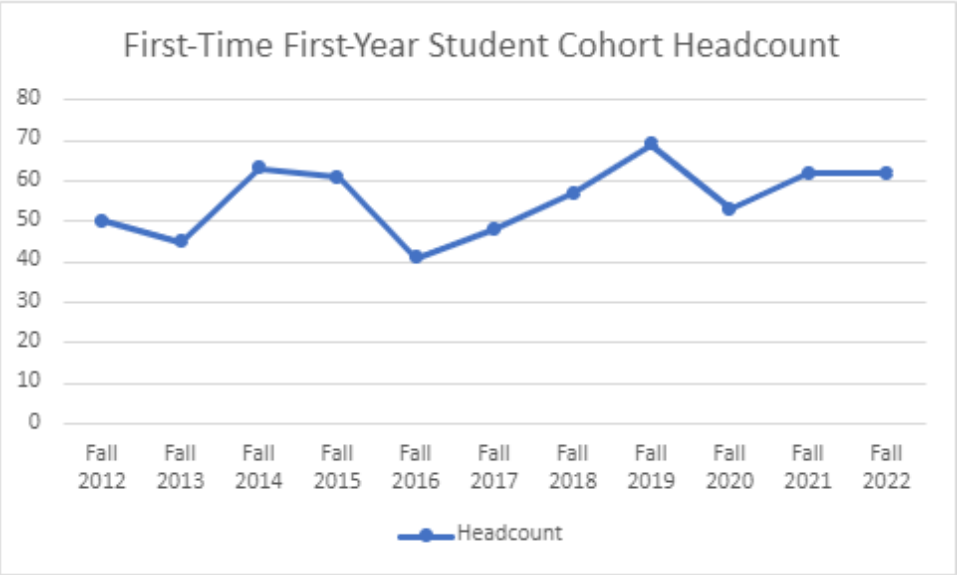
^ university data; this shows combined math and SDS majors (primary and secondary majors included) compared to numbers of graduates (primary and secondary majors included)

The stable to upward trends in graduation numbers are perhaps clearer when the singularly disruptive effects of the Pandemic are smoothed out. One way to do this is to look at annual averages of total degrees awarded across our majors during each 4-year period falling within the APR period:

Period	2016-2020	2017-2021	2018-2022	2019-2023
Ave. Degrees	120	120.5	119.5	125.25
Ave. Enrollment	584.75	584.25	573.5	557.25

This generally upward trend is also reflected in various measures of retention, such as 1-year retention rates, 4-year graduation rates, etc., and the graphs below plot these metrics. Note that this data is University data, computed for students whose primary major is Math or Statistics and Data Science; it

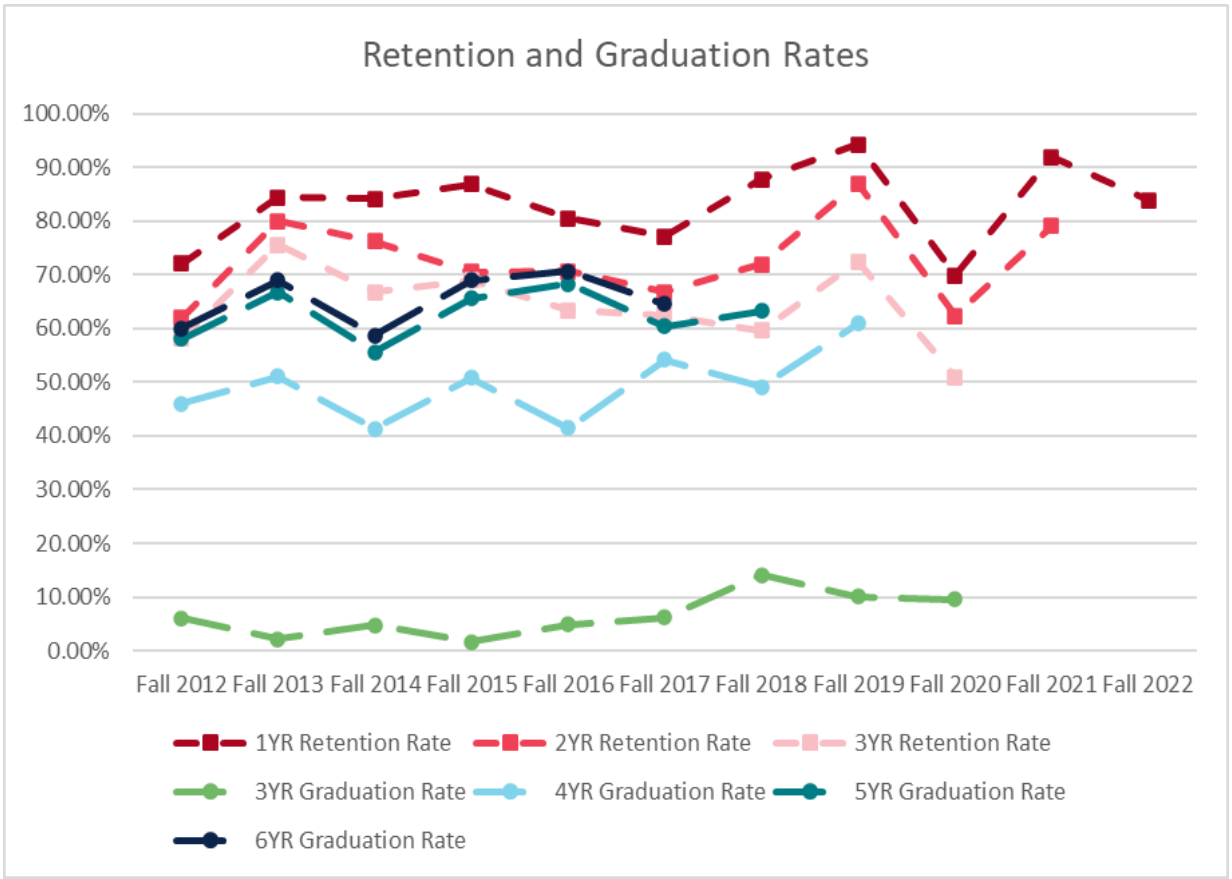
does not include any of our students for whom Math or SDS is a secondary major. The graph below shows the yearly cohort size for these students over the past decade:



^ university data

The graph below shows trends in retention data (1-year, 2-year, 3-year) and graduation rates (3-year, 4-year, 5-year, and 6-year) over the past decade.

Retention and Graduation Rates for students with primary major Math or Statistics and Data Science



^ ^university data

There are several additional points worth noting:

In this context, *retention* means retention at the University, not necessarily within one of our degree programs.

The 2020 data in the above chart fails to account for our *Global Direct* students. To mitigate the severe effects of the Pandemic on international students, the University introduced a new option in Fall 2020 for students who could not obtain visas to come to campus. They enrolled under the "Global Direct" location of our Online campus and began their studies online. Since our degree programs are not available to online campus students, these students enrolled as "No Major Selected" or under another major, and therefore do not appear in the University's counts for our majors. In Fall 2020, there were 4 full-time freshmen we advised as intended Math or SDS majors, all of whom were retained not just at the university, but in our major. One of these graduated already, and we expect the other three to graduate in May. Had these students been included as part of our Fall 2020 cohort, retention for this year would increase from 69.8% to 71.9%.

The Conference Board of Mathematical Sciences (CBMS) has conducted surveys to assess the impacts of the COVID Pandemic. The first phase (covering 2020—2021) has been completed, and their report shows that nearly one third of all four-year mathematics departments saw a decline of *at least* 10% in course enrollment from Fall, 2019 to Fall, 2020. Almost half of the schools had a decline of *at least* 5%. While course enrollment is not the same measure as major enrollment, the two are highly correlated, especially for upper division courses.

Retention rates provide only a partial picture of student success. Indeed, one has the fundamental equation:

Retention Rate + Graduation Rate + Attrition Rate = 100%

As such, decreases in the retention rate for a given cohort do not imply a corresponding increase in the rate of attrition. This important nuance is perhaps most clearly embodied by looking at 3-year data: while we see an overall downward trend in the 3-year retention rate of our majors, this is coupled with an overall upward trend in 3-year graduation rate, which reflects the generally high levels of quality and preparedness of our majors; see also the discussion in section H.12.a.

Note on enrollment numbers: we recruit and declare majors throughout the year. After spring graduation, our numbers are replenished somewhat by summer admits but we rely more on recruitment of students in fall and spring.

H.3. How the Undergraduate Curriculum Reflects the Basic Goals of the Academic Program

Distilling the goals articulated in sections H.1.a.-H1.b., the overarching goals of our academic programs are:

1) Expand the community of students we serve through education in the mathematical sciences.
2) Empower these students to develop mathematical, statistical, data science, and critical thinking skills for use in productive 21st century careers.

H.3.a. Service Offerings

By many metrics, we are one of the most prolific service departments at the University, and our lower division (below 300) course offerings and commitment to their relevance and quality reflect our deep commitment to our primary goals, not just within the mathematical sciences, but across all subjects and disciplines represented at the University of Arizona. We begin with a discussion of our extensive service mission.

Most Math courses with 3 or more units numbered at 106 or above satisfy the math foundations requirement. We separate such courses into entry-level (up through pre-calculus, 106- 120R), and service (122A/B-322) and exclude courses mostly taken by our majors and minors. In addition, we offer Math 100, which does not satisfy the foundations requirement but prepares students to take a course that does.

Course number	Description
Preparatory	
Math 100	Math Lab, Math elective credit
Math Foundations/Entry	
Math 106	Exploring and Understanding Patterns, Functions, and Modeling for Elementary Teachers
Math 107	Exploring and Understanding Data
Math 108	Modeling with Algebraic and Trigonometric Functions
Math 112	College Algebra Concepts and Applications
Math 113	Elements of Calculus
Math 116	Calculus Concepts for Business
Math 119A	Mathematics of Biological Systems: A Calculus Based Approach
Math 120R	Calculus Preparation
Math Foundations/Service	
Math 122A/122B	Functions for Calculus/First Semester Calculus
Math 125	Calculus I
Math 129	Calculus II
Math 163	Basic Statistics
Math 223	Vector Calculus
Math 243	Discrete Mathematics in Computer Science
Math 254	Introduction to Ordinary Differential Equations
Math 263	Introduction to Statistics and Biostatistics
Math 302A/B	Understanding Elementary Mathematics, I &II
Math 322	Mathematical Analysis for Engineers

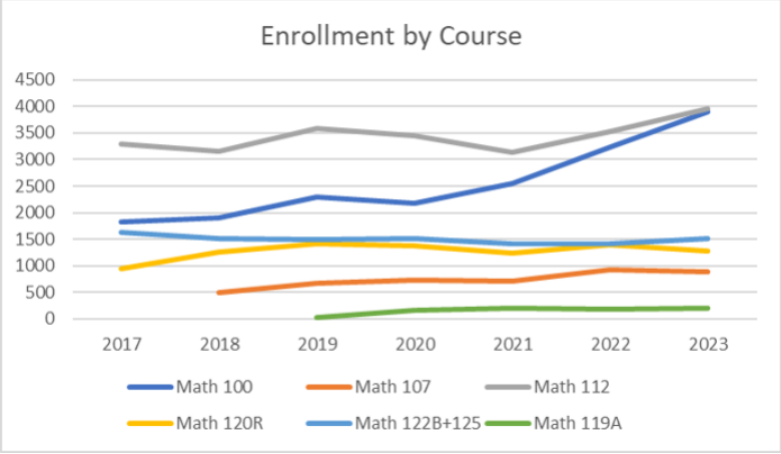
Service course enrollments and student credit hours (SCH) have increased significantly over the past two years due to a larger class size and increase in the Arizona Online populations. Service courses account for about 90% of our student credit hours.

FY	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Total SCH	59,616	59,001	59,128	58,993	58,428	62,018	65,102
Service Courses	89.9%	89.7%	90.0%	90.2%	88.9%	90.5%	90.5%

Service courses are taught primarily by career track faculty. There has been a shift in who teaches these courses over this APR period. The table below shows the growth of career track faculty teaching these courses from 2016 to 2023 and some declines in the graduate students and tenure track faculty teaching these courses, and a small increase in the post-doctoral faculty.

Service Course Teaching	2016-17	2022-23
Career Track	56%	67%
Grad Student*	29%	21%
Tenure	9%	4%
Post Doc	4%	8%
Staff	1%	0%

Enrollment has remained steady in courses like Precalculus (Math 120R) and Calculus I (Math 122B+ 125), while low-level courses such as Math 100 (preparatory) and Math 112 (College Algebra) have increased significantly.



Math Placement

Nearly all entering freshmen and most transfer students take an adaptive online placement exam. SAT/ACT Math scores are also used for placement. Placement scores and their choice of major

determine which entry-level math classes they take. After the end of the Fall semester, we review outcomes and adjust cut scores, as necessary.

New or Significantly Modified Service Courses

During the period of this APR, there have been several new courses created and existing courses modified or offered in new formats.

Math 100: Math Lab. This course has been modified a few times over the review period, in response to changes in placement, funding, and university-level mandates. Most notably, it moved from being a two-course, 7-week hybrid sequence (Math 100AX, followed by Math 100) to one 15-week course with a significant in-person component.

Math 106, Spring 2019: Exploring and Understanding Patterns, Functions and Modeling for Elementary Teachers. This course replaced Math 105, which was primarily completed by students in the College of Education Elementary Education and related teaching majors. The class size is 60-80 students. A major goal of this course is to better prepare students for our Math for Elementary Education (MATH 302A, B) courses. The class size is 60 students, taught in collaborative classrooms.

Math 107, Fall 2017: Exploring and Understanding Data. This course was created to address the needs of students in non-STEM majors who need to take a statistics course in their own department/college. Students take this course instead of College Algebra, and outcomes have improved dramatically for these students. The class size is 60-70 students, taught in collaborative classrooms.

Math 112: College Algebra. Early in this review period, the course was switched to a hybrid format. The outcomes were quite disappointing, and students and faculty did not like the changes. The course was subsequently returned to a larger in-person, collaborative format, with GTAs working in an assisting role in the classroom. The class size is now 60-70 students, taught in collaborative classrooms.

Math 119A, Spring 2019: Mathematics of Biological Systems: A Calculus-Based Approach. This course was developed based on a course at UCLA. It is a different approach to calculus for majors in Physiology, Biology, Ecology and Evolutionary Biology, Molecular and Cellular Biology and similar majors who did not need to complete calculus II. This course includes a few unique features, including a lower entry point to calculus (the prerequisite is only College Algebra, rather than Precalculus) and a lab time where students do significant work (using software) on applications from the biological sciences. The course has gained popularity among students and advisors, and the demand has continued to increase rapidly. The class size is 90-100 students, taught in collaborative classrooms.

Math 122A: Functions for Calculus went entirely online starting in 2020, for logistical reasons related to the pandemic. However, given the short duration of the course (three and a half weeks of content, followed by the first attempt at the final exam), we found this format suits the course. The course has remained online, and we have seen similar or better outcomes than when the class was in-person.

Math 186J, College Algebra Supplemental Instruction, and Math 196M, Calculus I Supplemental Instruction. These courses were added to the catalog to round out our supplemental instruction offerings in the calculus pathway. In these low-stakes sessions, students work collaboratively in small

groups with carefully selected questions that help them to develop persistence in problem-solving. These courses were built in consultation with Associate Dean Jim Baygents of the College of Engineering and are partially supported by the College of Engineering.

Math 108, Fall 2019: Modeling with Algebraic and Trigonometric Functions. This course was created in response to a change in Math 122A/B prerequisites (precalculus or placement only). Math 111 (trigonometry) was only required for two majors. Math 108 was created in cooperation with the Speech Language Hearing department and the Architecture department, to cover concepts in algebra and trigonometry that are needed in the two majors. These students take Math 108 in lieu of taking College Algebra and Trigonometry, saving two units of coursework that was unnecessary for their degree requirements. The class size is 60-70 students, taught in collaborative classrooms.

Math 263 Honors, Fall 2021. The Honors College supported the creation of an honors version of Math 263, Introduction to Statistics and Biostatistics. The course has run each semester since Spring 2022, with an enrollment ranging from 30 to 75 students, taught in collaborative classrooms.

Honors Courses

Historically, we have offered one honors section of Math 129, 223, and 254 per semester, and we recently added Math 263 and Math 323 to this list. If a student performed well in the prerequisite course, or had a high AP Calculus score, we would allow the student to enroll in an honors math course, regardless of enrollment in the W.A. Franke Honors College.

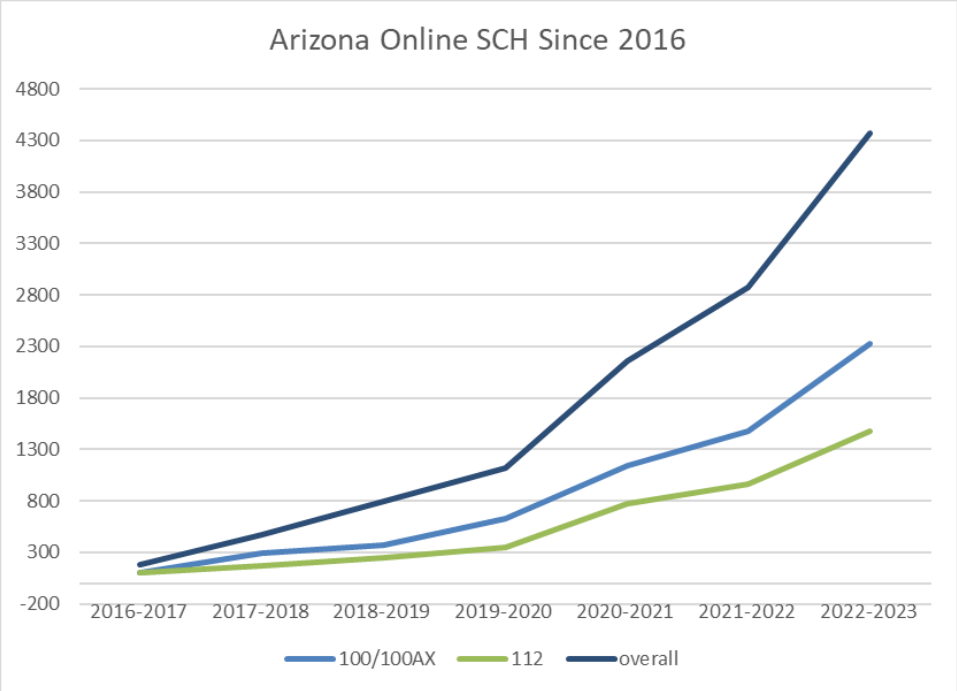
Recently we were asked by the Honors College to restrict enrollment in honors classes to only students enrolled in their program. We have had a difficult time filling Math 129, 223, and 323 honors sections even without this restriction, and limiting enrollment to only students in the Honors College would make this more challenging. In addition, our data indicates that strong performance in the prerequisite course is a better indicator for success than honors status, so we will no longer offer honors sections of these courses.

We continue to offer Math 254 and 263 as separate honors sections, as there is sufficient demand, and these courses were designed to be accessible to any honors student who has satisfied the enrollment requirements.
Any student in the Honors College can contract for honors for any course, so there are many opportunities for students to receive honors credit.

Arizona Online Campus, Courses

By far the largest enrollment growth the department experienced during this review period was in online courses. The University of Arizona online campus, Arizona Online, has expanded its degree offerings at a very quick pace, and nearly all of those degrees require some sort of math course. The net result is that Math department SCH from Arizona Online has increased on average by 75% per year since 2016. The bulk of this increase has been in Math 100 and Math 112.

Arizona Online	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Total SCH	181	474	791	1,120	2,157	2,878	4,371
Growth %	--	161%	67%	42%	93%	33%	52%



This rapid growth in demand has created difficulties in keeping up with staffing and has necessitated many curricular adjustments to handle larger enrollments. In addition, Arizona Online utilizes "rolling admissions" for new students, so we are often asked to accommodate increased student demand on short notice. The increase has also necessitated creating two new staff positions to support online course development and instruction.

Since 2016, these courses have been developed and run in an asynchronous online format: Math 100, 107, 112, 113, 116, 120R, 122A, 122B, 125, 129, 223, 243, 254, 263, and 313 (all offered every semester in this format), and Math 564, 566, 571A, 571B, and DATA 363 and 467 (each offered once per year in this format).

While most of our Arizona Online offerings are service courses, the Math and SDS minors are now available to Arizona Online campus students. The courses that apply to the online minors are:

- Online math minor courses: Math 122B, 129, 223, 243, 254, 313, 363
- Online statistics and data science minor: Math 122B, 129, 223, 313, 363, DATA 467

Retention Efforts

Success in math is a crucial indicator of student retention at the university. Course-level retention efforts are focused primarily on lower-level courses. (Retention efforts related to students in the Math/SDS majors/minors are detailed in Section H.12.c below.)

- Math 100, our preparatory course, is a big part of the department's retention efforts. This course enrolls many students identified as being at high risk for not being retained. Students begin the course with an initial knowledge check that identifies their current math skill set. The instructional team, which includes a sizable cadre of undergraduate teaching assistants, provides individualized instruction based on the student's specific needs. In short, we meet the students where they are, and help them get to where they need to be to secure placement into the next course. Schedule for Success and the Think Tank provide additional support.
- Through Wildcat Leap, the Math Department offers a 3-week online summer math workshop for incoming students to help review for the placement test or prepare for a first college math course.
- The Summer Calculus Workshop for Math 120R, 122B, 129, 223, 313 (Precalculus through Linear Algebra) recruits students from high-need high schools to participate in a 5-day workshop prior to the start of the fall semester. Participants in the program do problem-solving in small groups and start to develop community with the department and with each other.
- The instructors of Math 112 and 120R participate in Trellis Progress, a university-created program integrated into D2L, to do outreach to students not attending or struggling with the content. These communications, which are copied to academic advisors, include personalized messaging and suggestions for getting assistance or improving class performance. Department participation in Trellis Progress has increased significantly over the past several years, and many instructors use Trellis Progress in all the courses they teach.
- Supplemental instruction classes, Math 186J, 196L, 196M, 196N, 196V, and 396L support students taking Math 112, 120R, 122B, 129, 223, and 323, respectively. They offer students an opportunity to develop problem-solving and persistence within the context of the course content in a low-stakes environment.

H.3.b Major Programs

Recognizing that the majority of students we serve will not pursue a career in academia, our curricula reflect this goal by providing seven distinct emphases within our math major (described in section H.1.a. above) tailored to meet the future demands of a wide variety of careers.

Likewise, we closely monitor the skills and tools desired by companies hiring data scientists to ensure that our Statistics and Data Science degree remains relevant and helpful, making modifications to course content and offerings as needed. In Spring 2021 we conducted a survey of alumni and other industry contacts working in data and information science to obtain current information on the skills and competencies required by employers, and we have used the results of this survey to inform our SDS curriculum; for example, we added SQL to the SDS curriculum for Fall 2023 in response to this survey. See section H.5. below for a further discussion of this survey. Since Spring 2022, we have had a standing subcommittee of our Undergraduate Committee charged with overseeing our SDS curriculum and making adjustments as needed to maintain alignment with the primary goal articulated above. In particular, the committee has worked for the past year to transform our SDS degree into a College of Science wide degree in Data Science, with emphasis areas in several disciplines across the College, including two emphases in statistics which expand and refine our existing SDS degree, as well as emphasis areas in Computer Science and Molecular and Cellular Biology, with more emphases in the works. The new degree is in the final stages of approval, and we expect to begin offering it in Fall 2024.

We offer a version of our SDS BS degree in Bejing, China at the Capitol University of Economics and Business (CUEB). Our instructional responsibilities for the CUEB program began in Spring of 2023. We have about 70 students in the program now, but we expect this to grow to around 500 in the coming years, and now have three career track faculty members ("Global Professors") in Beijing teaching at CUEB with plans to hire more as the program grows. This program's creation required extensive work on the part of our SDS faculty, undergraduate committee, and academic and advising staff. This degree program includes all the core courses of our SDS program plus six additional courses we have created specifically to be taught at CUEB. The CUEB SDS degree program is now a very substantial expansion of our undergraduate program, and our administrative and instructional commitments.

We have worked with this international partner to adapt our existing SDS curriculum to serve the unique needs of this student population. Note that these 70 students are not reflected anywhere in the number of majors elsewhere in the document.

Overall, our curriculum and course requirements are well aligned with the recommendations summarized in the 2015 CUPM (Committee on the Undergraduate Program in Mathematics) Curriculum Guide to Majors in the Mathematical Sciences of the Mathematical Association of America and its online course area study group reports. In 2017, CUPM published an Update on Actuarial Mathematics; while we are in alignment with the best practices outlined in the report, discussions regarding providing more substantial support (possibly in the form of an undergraduate certificate) have stalled due to our lack of faculty with knowledge and experience in this field.

H.4. Accrediting Body

As described above, the Secondary Mathematics Education Program holds accreditation from the Arizona Department of Education; the next review will be in 2030.

The rest of our curriculum is not prescribed by any accrediting body.

H.5. Comparison of Degree Programs to Similar Programs

We have reviewed the degree/major offerings at the peer institutions used elsewhere in this report. Some notable points of comparison are as follows:

- All the institutions in our peer group have an actuarial program of some sort. For most, it is a major (or track) in the mathematics department. Among the rest, one has a track in their statistics major, one has a minor in the statistics department, and one has a major in the school of business. We have discussed the possibility of an undergraduate certificate in actuarial science and currently offer advising and support to students preparing for actuarial careers, but we do not have faculty resources to commit to a formal program at this time.
- Most of our peer institutions have introduced Data Science (or Data Analytics) majors or tracks in the last several years. A couple of these have tracks in different areas, similar to the updated version of our BS that we have proposed for 2024.
- In terms of major course work, requirements vary widely.
    - Most majors in mathematics, statistics, or data science require some computer programming like we do.

- Most mathematics majors have similar major units required to ours, within 1-2 courses more or less, with University of California – Riverside as an outlier (adjusting for their quarter system units, their Pure Math BS may include the equivalent of up to 6 additional courses beyond what our Comprehensive Math emphasis requires, though it appears that some of these courses may be selected from Computer Science or "related" course offerings). Most of the mathematics majors also have emphases or tracks like we do, though usually fewer than we offer.
- The Data Science/Analytics offerings vary more widely in terms of numbers and types of courses/units required. Our existing major in Statistics & Data Science would fall on the low end in terms of units required, but a little higher in terms of the amount of computer programming course work included. Our proposed updated BS in Data Science still requires roughly 6 fewer courses than the programs with the heaviest course loads.
- It is more common to offer both a BA and a BS in mathematics than in Data Science (we currently offer both for either major). Where both are available, the BA usually requires fewer major courses (our major requirements are currently the same, regardless of BA or BS). Half of the institutions we looked at that offer a major or track in Data Science/Analytics offer BS only.

The Secondary Mathematics Education Program (SME-Program) structures the mathematics education track in the math major and is designed for students seeking secondary education licensure in mathematics in Arizona and other states upon completion of their BA or BS degree. The SME-Program is aligned with national teacher education standards including the Mathematical Education of Teachers (CBMS 2012) and the Standards for Preparing Teachers of Mathematics (Association of Mathematics Teacher Education, 2017) and the Interstate Teacher Assessment and Support Consortium (InTASC) Professional Teaching Standards (2011). SMEP is accredited from the Arizona Department of Education, and students can acquire licensure in other states due to our program's curriculum, structure, and field practicum internship experiences.

Our undergraduate committee continually evaluates courses for content and service to our student populations. Some recent and ongoing projects include:

- Calculus text + homework
- 223: coming revamp/ restructure AND removing it as prereq.
- SDS (see notes below)
    - DATA 201
    - Discussing moving 498A one semester earlier to include resume and other career/graduate school preparation

In Spring 2022, our undergraduate committee (UGC) convened a working group to discuss the existing Statistics & Data Science major to consider how we can stay current as the training needs for future data scientists evolve. The initial charge was as follows:

1. Form an advisory group, consisting of various industry contacts, including some of our recent graduates (undergraduate and graduate programs) that work in data science.

2. Collect information from advisory group members about the most needed skills for a student graduating with an undergraduate degree in SDS. This will likely include information about both hard and soft skills.
3. Investigate curricular offerings in successful data science undergraduate degree programs at other peer institutions, to determine whether our curriculum matches sufficiently well.
4. Propose curricular changes based on your findings, and present those to the Undergraduate Committee.

The group reached out to contacts working and/or hiring in the field of data science with a survey and made recommendations to the UGC based on the findings. The group identified the following issues and steps to address them.

- From our survey, it was clear that SQL and data management are important skills for a working data scientist. To address these needs, we will propose to UGC that ISTA 322 "Data Engineering" be added as a co-requisite to DATA 363. This will have the additional effect of making the Python course (CSC 110 or ISTA 130) a prerequisite. This may reduce the number of minors but seems worthwhile even so.
- Machine learning. The current iteration of our capstone course DATA 498A is essentially a machine learning class, however, we think it would benefit our students to create a new separate machine learning class and use DATA 498A as a more traditional capstone in which students bring all their previous knowledge to bear on a substantial data science project.
- Portfolios. We believe that it will benefit students entering the workforce to have a portfolio of projects from their DATA classes which highlight their skills. This will allow employers to directly see the skills our students have and help students to articulate those skills to employers. In AY22-23 we hope to identify a way to have students create portfolios of projects they created in their DATA courses. This portfolio will be assessed in DATA 498A.

The working group has continued to meet, helping with development of the proposed Data Science degree updates, discussing issues related to the CUEB program in China, and serving in an advisory capacity to the UGC as needed.

H.6. Challenges with Course Availability

Since 2020, the average math placement level for incoming students has dropped significantly, thus putting pressure on our lowest level courses, particularly Math 100, Math 107, and Math 112. Recent economic and social trends have made it extremely difficult to hire adequate numbers of skilled instructional faculty and post-docs. Our current salary structures for CT faculty exacerbate that situation. The increase in demand for statistics and data science-related courses, and the creation of the Statistics/Data Science major and minor has strained our ability to cover such courses. Many of our tenured/tenure-track faculty do not have expertise in this area. We have worked to address this need in a number of ways, including hiring tenure-track faculty, a senior lecturer, and a professor of the practice in Statistics/Data Science. However, we expect the demand for the major and for coursework related to statistics, and especially in machine learning, to continue to grow.

We have an impending issue with our Math 100 course funding. Math 100 has a unique course design, utilizing a large group of UTAs to support individualized student learning. The course was supported by a student course fee, which covers the UTA costs, equipment, and administrative costs. Because the university has eliminated course fees, the financial support for the course is in question. The Math 100 enrollment numbers have been increasing dramatically in recent years (see table below), so this is particularly problematic.

Year	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Math 100 enrollment	1820	1903	2290	2181	2553	3223	3900

H.7. Confirmation of All Syllabi Containing Learning Outcomes

Most multi-section courses are coordinated, and instructors are given template syllabi that include consistent learning outcomes. Vetted course syllabi for upper division courses, which include learning outcomes, are made available to new instructors via a department database.

H.8. Active Learning Strategies

A recent survey demonstrated extensive use of active learning strategies among our department members. 77% of respondents use active learning “every day” or “almost every day”, while less than 10% indicated that they employ these strategies “never” or “less than once a week”.

In addition to the many individuals who have used active learning in their classrooms for years or even decades, the department has made a strong commitment to collaborative teaching and learning in several courses, including:

Math 106, 107, 108, and 112. Due to changes in GTA funding, all courses below precalculus were reconfigured and are now taught in classes of size 60, with an experienced instructor and one .25 FTE GTA. All sections of these classes incorporate active learning strategies and are taught in Collaborative Learning Spaces (CLSs).

Math 363 is taught in a flipped format, with content delivered via video, and class time spent on group activities to reinforce concepts. This course is also taught in a CLS.

Math 119A includes a substantial collaborative component in the form of a weekly lab, which is held in a CLS.

The department obtained an ISLE grant through the office of Academic Affairs, which helped to support the conversion of an old library space within the Math Tower into a 44-seat collaborative classroom. Math 120R is taught in this room during most hours of the day, Monday through Friday. It is also used for our Math Instruction Colloquium and various workshops and meetings outside class times.

ULAs and UTAs have been utilized in Math 100, Math 107, Math 113, and to a lesser extent in Math 112, 129, and 223. We have continued to grow the ULA and UTA programs and have created a professional development course (Math 391) to help the ULAs and UTAs to acquire and apply the skills learned in the classroom.

H.9. Use of Instructional Technology Within Program Courses

The department embraces the use of technology to enhance student interaction, communication, demonstration, homework completion, and grading. Some of the instructional technologies used include:

- In 100-200 level coordinated courses, every section has a D2L site. GTA supervisors and course coordinators have access to all D2L sites in their course.
- Non-term specific Instructor-only D2L sites provide content material to support instructors (e.g., section comments, homework, quizzes, exams, videos, handouts, worksheets).
- Each coordinated course has a Microsoft Teams channel and shared drives to disseminate information, collaborate on and share material, and discuss issues relating to the teaching of the course.
- Required online homework (using ALEKS, MyMathLab, WebAssign, and/or Gradescope) is utilized in all coordinated courses. In the calculus sequence, this includes department created questions and practice.
- The calculus sequence has department-maintained quiz and exam bank in WebAssign (from COVID semesters).
- Gradescope is used extensively for grading written homework, in an effort to improve transparency, consistency, and efficiency. Gradescope allows for anonymous grading, as well as distributed grading (for classes with a teaching team or and GTA/ULA/UTA who assists with grading).
- Many instructors continue to make live classes available via Zoom for students who are unable to attend in person, and/or record the class meeting and make it available via D2L.
- All online courses (except project-based courses) require proctored exams. We use Honorlock for this purpose.
- A survey of department members indicated that the following are used regularly for instruction: Desmos, Excel, FlipGrid, Geogebra, G-Suite, Google Jamboard, Julia, Jypter, Kahoot, Mathematica, Mathigon, Nasa dynamic data access website, Octave, Piazza, Polypad, Python, R, R Console, R Studio, Socrative, Solve Me Mobiles, Top Hat, virtual manipulatives, and zyBooks

H.10. Online Courses

We do not expect to offer a full undergraduate degree program online any time soon. We do have just enough online courses to offer the Math and the SDS minors online, but barely so.

Math courses: MATH 122A & 122B (calculus I), MATH 129 (calculus II), MATH 223 (vector calculus), MATH 243 (discrete math), MATH 254 (intro to ordinary differential equations), MATH 313 (intro to linear algebra), MATH 363 (statistical methods), MATH 422 (advanced applied analysis; under development Sp 24). MATH 485 (Mathematical Modeling) - has been offered but may not be a regular offering unless we have sufficient demand to run more than one section.

SDS minor courses: MATH 122A & 122B (calculus I), MATH 129 (calculus II), MATH 223 (vector calculus), MATH 313 (intro to linear algebra), DATA 363 (statistical methods), DATA 467 (applied linear models)

Currently have 7 students enrolled in the online math minor; 2 in the online SDS minor

H.11. Electronic Copy of Undergraduate Student Handbook

View/download: https://www.math.arizona.edu/files/APR2024/uhandbook.pdf

H.12. Undergraduate Students

H.12.a Quality of Students Selecting Degree Programs

We are very proud of the quality of students that we attract and retain in our majors.

To assess the quality of students in our degree programs relative to other fields and degree programs at the University, we analyze average GPA, time to degree, graduation rates, retention, and awards.

The table below shows the average GPA for graduates of the specified major in each year of the APR.

	Average Degree GPA						
	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Mathematics	3.30	3.30	3.35	3.28	3.42	3.48	3.44
Statistics & Data Science				3.23	3.28	3.50	3.50
Astronomy	3.23	3.04	3.48	3.34	3.34	3.55	3.45
Chemistry	2.85	3.08	3.00	3.28	3.27	3.22	3.44
Computer Science	2.95	3.24	3.26	3.28	3.31	3.36	3.38
Physics	3.38	3.26	3.43	3.30	3.29	3.61	3.43
College of Science	3.15	3.24	3.27	3.3	3.36	3.43	3.47

^ university data

Note that Math is above the College of Science average in all years but 2019—2020, where it falls 0.02 points lower. Statistics and Data Science is above the College of Science average for the past two years, and slightly below for the first two years of the degree's existence.

For reference, at UArizona, Summa Cum Laude is awarded to candidates whose grade-point-average is 3.900 or higher; Magna Cum Laude is awarded to candidates whose grade-point-average is 3.700-3.899; Cum Laude is awarded to candidates whose grade-point-average is 3.5000-3.699.

	Latin Honors		
	Cum Laude	Magna Cum Laude	Summa Cum Laude
Mathematics	15%	17%	16%
Statistics & Data Science	20%	11%	20%
Astronomy	18%	16%	16%
Chemistry	13%	12%	8%
Computer Science	15%	14%	8%
Physics	18%	15%	17%
College of Science	15%	16%	13%

< university data

The table below shows the average time to get a degree for majors across the College of Science over the APR period, as well as the College of Science average. Note that the average time to degree for the Statistics and Data Science major is among the lowest in the College of Science.

Major	Average Time to Degree in Years
Applied Physics	4.19
Astronomy	3.96
Biochemistry	3.93
Bioinformatics	4.34
Biology	3.94
Chemistry	4.11
Computer Science	4.22
Ecology & Evolutionary Biology	4.37
Environ Hydrology & Water Res	4.60
Geosciences	4.04
Hydrology and Atmospheric Sci	3.69
Mathematics	4.11
Molecular & Cellular Biology	3.97
Neuroscience & Cognitive Sci	3.88
Physics	4.06
Psychological Science	3.64
Psychology	3.87
Science Education	4.04
Speech, Language & Hearing Sci	3.64
Statistics and Data Science	3.66
College of Science Average	3.96

^University data (Time to degree completion is calculated based on the student's entry term in academic career. Includes all students – Student Degrees Analytics Dashboard)

The table on the following page gives the emphases (subplans) and counts of the mathematics and statistics & data science degrees awarded since 2017.

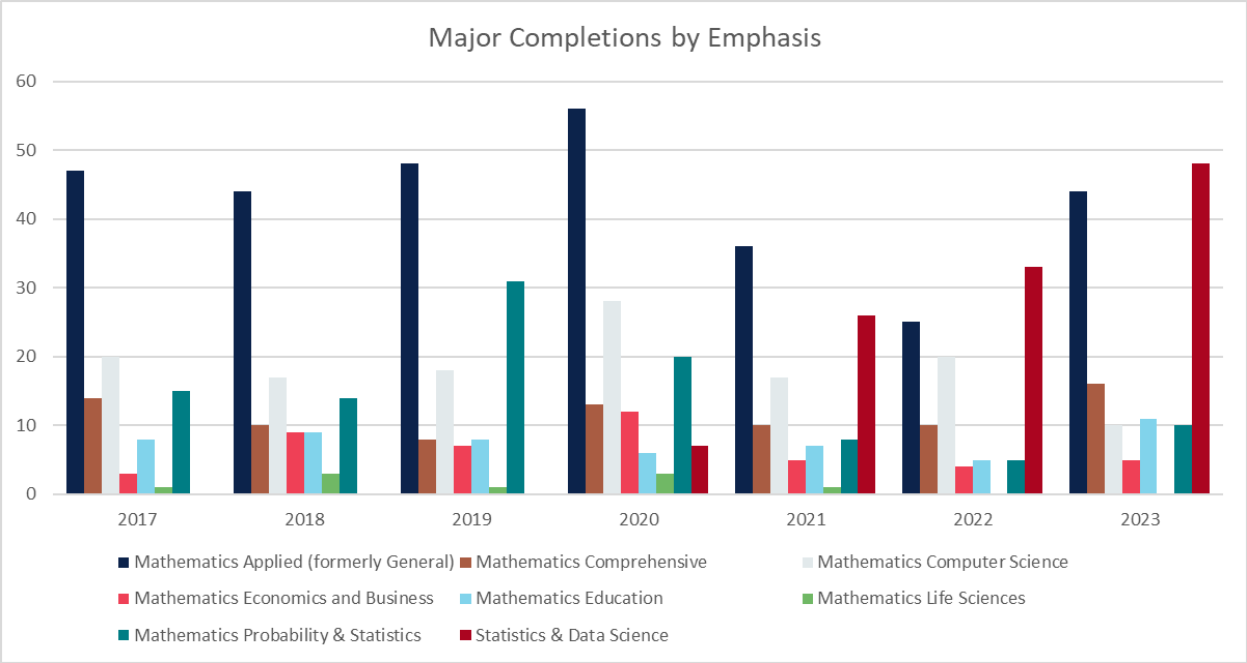
		Degrees Awarded						
Major	Emphasis	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Mathematics	Applied (formerly General)	47	44	48	56	36	25	44
	Comprehensive	14	10	8	13	10	10	16
	Computer Science	20	17	18	28	17	20	10
	Economics and Business	3	9	7	12	5	4	5
	Education	8	9	8	6	7	5	11
	Life Sciences	1	3	1	3	1		
	Probability & Statistics	15	14	31	20	8	5	10
Mathematics total		108	106	121	138	84	69	96
Statistics & Data Science					7	26	33	48
Grand Total		108	106	121	145	110	102	144

^ University data

The first cohort of students in the SDS degree was enrolled in Fall 2018, and we see steady growth in the number of graduates of this program its inception. At the same time, the number of graduates in the Mathematics Major has generally decreased over the same time period, in large part because many students graduating with a degree in SDS would have graduated with a degree in mathematics had the SDS degree been unavailable: indeed, the single largest relative drop from average number of degrees awarded during 2017—2020 to average degrees awarded 2021—2023 was in the Probability & Statistics emphasis, which saw nearly a 62% decline in average degrees awarded over these time spans.

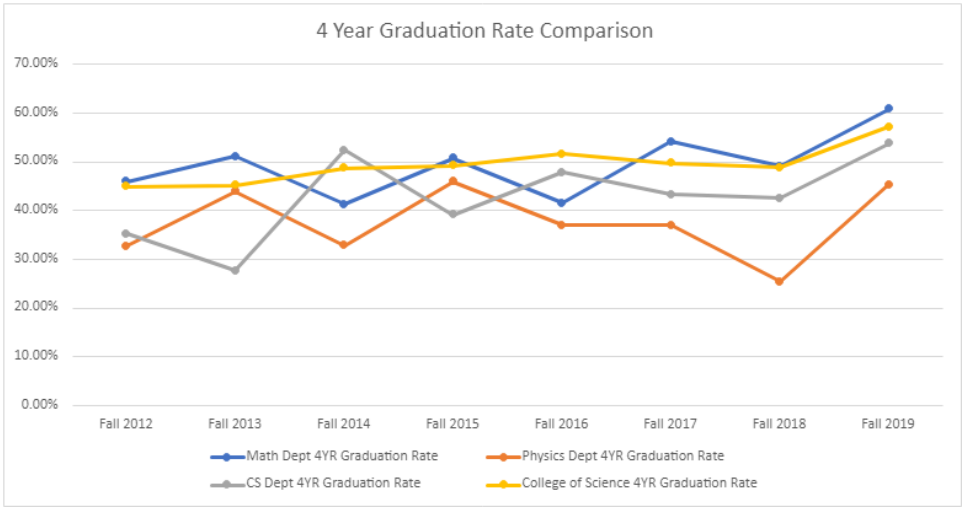
The large number of students graduating in 2020 (145 total) relative to all other years is noteworthy. The University of Arizona held its annual spring break as usual in early March 2020, but due to the onset of the global COVID-19 pandemic, the University remained closed for the rest of spring semester that year, and classes resumed only online. We suspect that a number of students who may have otherwise opted to spend more time in college decided to graduate that spring, rather than face an increasingly uncertain future at the University.

The chart on the following page gives a visual representation of the composition of our completed majors across the different emphases and in Statistics and Data Science.



^ university data

The 3-, 4-,5-, and 6- year graduation rates for students with primary major Math or Statistics & Data Science were discussed in section H.2.b. The graph below compares the 4-year graduation rate of students with a major in the Math Department to those of students majoring in some peer departments (Computer Science and Physics), as well as to students with a major in the College of Science:

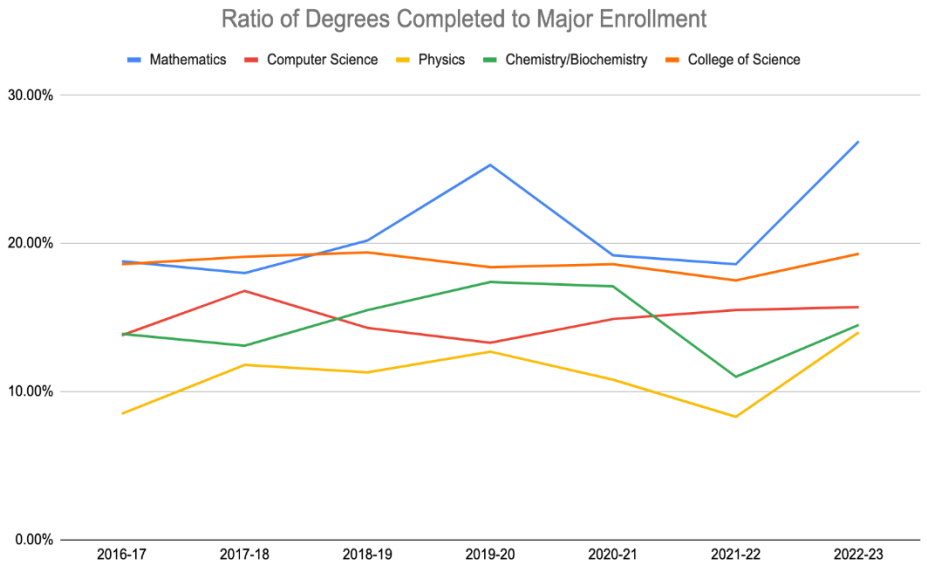


To make these comparisons in a way that better accounts for considerable variation in program and cohort size, a natural metric to analyze is the *ratio* of degrees awarded by a given department to the total enrollment across all of that department's major programs. In an idealized model where every enrolled student graduates in exactly 4 years and each annual cohort are exactly the same size, this ratio would be 25%. Among our closest peer departments (Computer Science, Physics, Chemistry/ Biochemistry) and relative to the College of Science-wide numbers, Mathematics is considerably closer to this idealized ratio across the APR period:

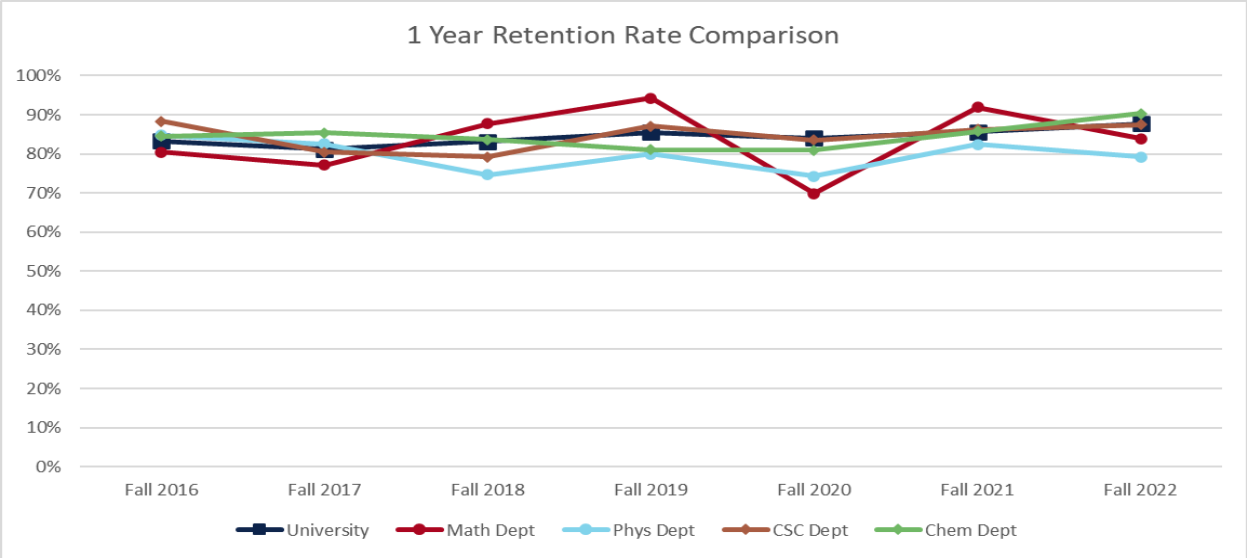
	Degrees Completed / Major Enrollment						
	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Mathematics	18.8%	18.0%	20.2%	25.3%	19.2%	18.6%	26.9%
Computer Science	13.8%	16.8%	14.3%	13.3%	14.9%	15.5%	15.7%
Physics	8.5%	11.8%	11.3%	12.7%	10.8%	8.3%	14.0%
Chemistry/Biochemistry	13.9%	13.1%	15.5%	17.4%	17.1%	11.0%	14.5%
College of Science	18.6%	19.1%	19.4%	18.4%	18.6%	17.5%	19.3%

^ university data (completions per year divided by fall census enrollment for each department)

This data is plotted in the graph below. Note that Computer Science awarded an average of approximately 200 degrees per year of the APR, while Physics awarded an annual average of about 29 degrees. Mathematics awarded an average of about 119 degrees per year, roughly in the middle of these peers.



The graph on the following page compares 1 year retention rates for first-year full-time students with primary major in the Math Department and these peer departments, as well as University-wide rates. Recall that *retention* means retention at the University, not within a specific major, department, or college.



^ university data (first-year cohort data, primary majors only)

Aside from a noticeable dip in Fall 2020, retention rates in the Math Department are on par with peer departments and University-wide rates, lying above these rates in 3 of the APR period years, and below in 4. The drop-in retention rates for Math and Statistics and Data Science in Fall 2020 was discussed in detail in sections H.2.a-H.2.b and is considerably accentuated in the above graph by the comparatively high retention rates in the adjacent years 2019 and 2021.

The preparation of incoming first-year students electing to major in math or SDS is a factor in their retention, both within their selected major and at the university in general. One way to gauge their preparation is to look at the first math course taken at the university; as shown in the table below, we see a larger percentage of our incoming majors placing at or below the level of College Algebra. Our primary strategies to mitigate the overall downward trends in placement are:

1) Proactive recruitment to our majors of incoming students University-wide who have placed into Calculus or above. These recruitment efforts will be discussed in more detail in 3.b.2 below.
2) Expanded advising and mentoring (e.g., peer mentoring) support for incoming first-year students with lower placements, as discussed in section H.12.c and H.12.e.

FY first course	Fall 2012	Fall 2013	Fall 2014	Fall 2015	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
Below Precalc	8.3%	12.5 %	12.9 %	11.1 %	25.0 %	19.0 %	13.0 %	9.6%	19.0 %	19.0 %	23.3 %
Precalc	10.0 %	10.4 %	12.9 %	11.1 %	13.6 %	12.1 %	10.1 %	12.3 %	12.1 %	20.7 %	23.3 %
Calc I	30.0 %	35.4 %	41.4 %	30.6 %	20.5 %	32.8 %	31.9 %	30.1 %	19.0 %	25.9 %	21.7 %
Calc II or higher	51.7 %	41.7 %	32.9 %	47.2 %	40.9 %	36.2 %	44.9 %	47.9 %	50.0 %	34.5 %	31.7 %

As pointed out in section H.2.b, retention rates do not tell the whole story, due to the fundamental equation: retention + graduation + attrition = 100%. Our students have a markedly higher than average 3-year graduation rate in comparison to peer departments, the College of Science, and the University:

	University		College of Science		Math Dept		Phys Dept	
Entry Cohort	Headcount	3YR Graduation Rate	Headcount	3YR Graduation Rate	Headcount	3YR Graduation Rate	Headcount	3YR Graduation Rate
Fall 2016	5978	2.8%	1164	3.0%	41	4.9%	46	2.2%
Fall 2017	5875	3.1%	1332	3.6%	48	6.2%	46	0.0%
Fall 2018	5992	3.5%	1381	4.6%	57	14.1%	63	3.2%
Fall 2019	6017	3.1%	1584	3.9%	69	10.1%	75	2.6%
Fall 2020	6359	4.2%	1388	3.9%	53	9.5%	35	0.0%
average	**6044.2**	**3.3%**	**1370**	**3.8%**	**54**	**9.0%**	**53**	**1.6%**

^ source: university data (first-year cohort data, students are counted once)

The department currently controls over $30,000 in scholarship money for undergraduates. The webpage https://www.math.arizona.edu/academics/undergrads/scholarships contains descriptions of all awards, most of which are merit-based. We think our students are impressive, but we are not the only ones. Some examples of awards earned by our majors through other departments or organizations are included below.

At least one of our graduating students or recent alumni has been awarded an NSF Graduate Fellowship (click for list) each year during this APR period.

Zachary Schlamowitz was awarded an Astronaut Foundation Scholarship in 2022.

In the fall semester, each department in the College of Science selects an Outstanding Graduating senior for December commencement. In the spring semester the Outstanding Graduating senior for May commencement and the Excellence in Research Award recipient are selected. These selections are forwarded to the College of Science for consideration of the College of Science awards. Many of the Outstanding Graduating Seniors and Excellence in Research award recipients selected by other departments in the College of Science have an additional major in Mathematics or Statistics & Data Science. Several of these have won the college-wide awards for Outstanding Senior or Excellence in Research, as well!

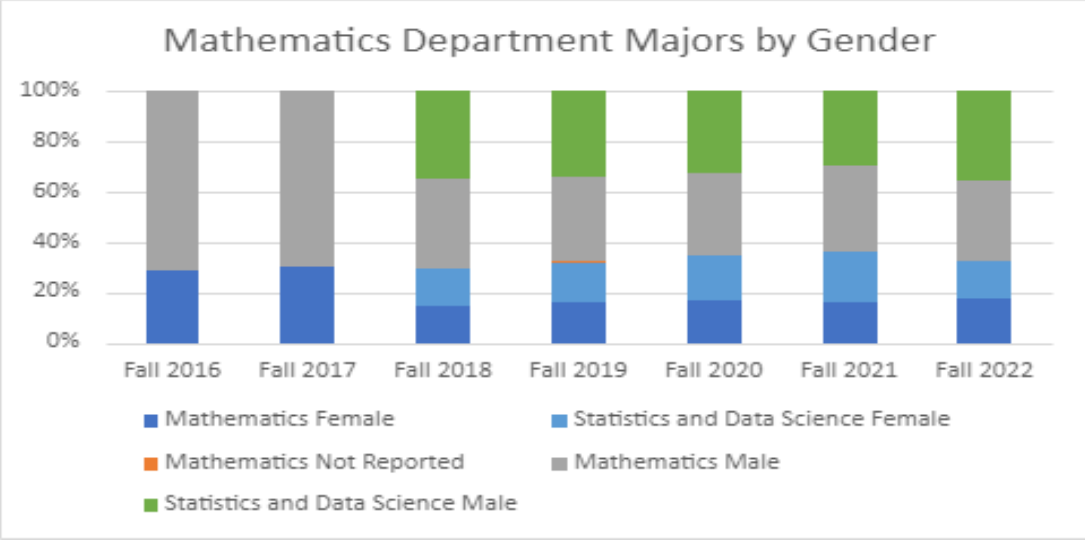
H.12.b. Gender and Race/Ethnicity Composition of Students

The table below shows gender demographics for enrollments across our two majors. During the APR period, just under 1/3 of our enrolled majors have been female.

Major	Sex	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
Mathematics	Female	29%	30.3 %	29.5%	31.6%	34.3%	31.8 %	35.3 %
	Not Reported		0.2%	0.2%	0.2%	0.3%		
	Male	71%	69.5 %	70.4%	68.2%	65.5%	68.2 %	64.7 %
	Total count	576	590	550	450	391	355	334
Statistics and Data Science	Female			30.0%	32.5%	35.0%	41.1 %	29.4 %
	Male			70.0%	67.5%	65.0%	58.9 %	70.6 %
	Total count			50	122	183	192	201

^ university census data (includes both primary and secondary majors)

The bar chart gives a quick graphical representation of this data:



^ university census data (includes both primary and secondary majors)

The table on the following page provides data on annual degrees awarded by major and gender. During the APR period, approximately 29% of the graduates of our major programs have been female.

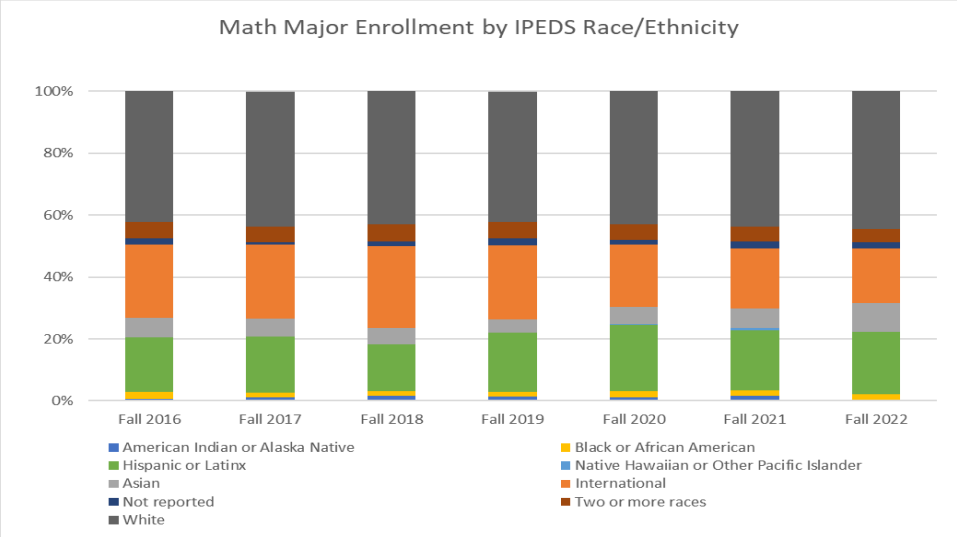
Degrees Awarded by Major & Gender								
		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Mathematics	Female	27.4%	36.8%	30.9%	19.3%	28.6%	27.5%	32.3%
	Male	72.6%	63.2%	69.1%	80.7%	71.4%	72.5%	67.7%
	Count	106	106	123	135	84	69	96
Statistics & Data Science	Female				0.0%	15.4%	48.5%	30.6%
	Male				100.0%	84.6%	51.5%	69.4%
	Count	0	0	0	7	26	33	49

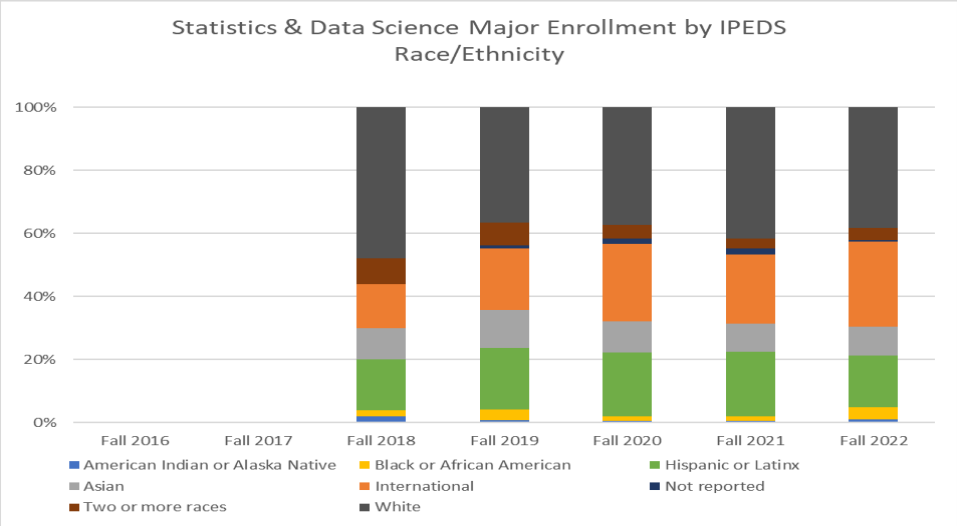
^ Completion data source: Math Center degree records (double majors are counted twice: includes 1 Male double major in 2019-20, 2 Female and 2 Male in both 2020-21 and 2021-22, and 2 Male in 2022-23)

The tables and charts below provide data on the race/ ethnicity composition of our majors. Note that the category "more than one race" includes all individuals who identify as belonging to more than one racial group, and as such may include students who belong to one or more underrepresented minority (URM) groups. During the APR period, approximately 15% of enrolled students were Hispanic/ Latinx, while 21.5% belonged to exactly one of the NSF defined URM groups (American Indian or Alaska Native, Black, or African American, Hispanic or Latinx, Native Hawaiian or Other Pacific Islander).

Enrollment Numbers by Major and Race/Ethnicity								
Major	**IPEDS Race/Ethnicity**	**Fall 2016**	**Fall 2017**	**Fall 2018**	**Fall 2019**	**Fall 2020**	**Fall 2021**	**Fall 2022**
Mathematics	American Indian or Alaska Native	3	7	9	6	4	6	1
	Asian	37	35	30	19	21	23	31
	Black or African American	13	9	9	7	8	6	6
	Hispanic or Latinx	102	106	82	86	84	69	67
	International	136	141	145	108	79	68	59
	Native Hawaiian or Other Pacific Islander					1	2	
	Not reported	11	5	8	10	6	8	7
	Two or more races	31	29	30	24	20	17	14
	White	243	258	237	190	168	156	149

	URM Total	118	122	100	99	97	83	74
	Total	**576**	**590**	**550**	**450**	**391**	**355**	**334**
Statistics & Data Science	American Indian or Alaska Native			1	1	1	1	2
	Asian			5	15	18	17	18
	Black or African American			1	4	3	3	8
	Hispanic or Latinx			8	24	37	39	33
	International			7	24	45	42	54
	Not reported				1	3	4	1
	Two or more races			4	9	8	6	8
	White			24	45	68	80	77
	URM Total			10	29	41	43	43
	Total			**50**	**123**	**183**	**192**	**201**
URM Grand Total		118	122	110	128	138	126	117
Grand Total		**576**	**590**	**600**	**573**	**574**	**547**	**535**





^ University census data (includes both primary and secondary majors)

The tables below provide data on annual degrees awarded by IPEDS Race / Ethnicity. During the APR period, approximately 16.6% of the graduates of our major programs have come from URM groups, with 15.3% identifying as Hispanic/ Latinx. While the percentage of degrees awarded to Hispanic/ Latinx students is on par with the total proportion of such students enrolled in our programs, there is a significant drop (from 21.5% to 16.6%) when comparing the proportion of enrolled URM students to the proportion of degrees awarded to such students over the APR period. This strongly suggests that we need to boost retention efforts with our non-Hispanic / Latinx URM student populations.

Math Major Degrees Awarded by IPEDS Race/Ethnicity							
IPEDS Race/Ethnicity	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
American Indian or Alaska Native			1		1	1	
Black or African American	2	2	2	1			
Hispanic or Latinx	20	20	15	14	18	16	14
Asian	10	6	6	7	9	3	3
International	25	29	37	46	19	21	25
Not reported	2	2	4	6	1	1	2
Two or more races	5	3	9	9	3	3	8
White	53	51	57	64	46	31	54
URM Total	22	22	18	15	19	17	14
Total	117	113	130	147	96	75	106

^ university data on major completions (double majors are counted for each major). Note that the "Two or more races" category hides some of the URM students; for example, our three math graduates with

Native Hawaiian or Pacific Islander ancestry are listed as Two or more races in the official IPEDS reporting.

Statistics & Data Science Major Degrees Awarded by IPEDS Race/Ethnicity							
IPEDS Race/Ethnicity	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Black or African American				1			1
Hispanic or Latinx				2	6	10	6
Asian					2	3	6
International				1	13	10	26
Not reported				1		2	
Two or more races				1	2		2
White				1	9	14	20
URM Total				3	6	10	7
Total				7	32	39	61

^ university data on major completions (double majors are counted for each major).

H.12.c Recruitment of Underrepresented Ethnic Groups

The Math Center engages in a number of activities for recruiting and retaining students from underrepresented ethnic groups. These activities are part of our regular recruitment and retention efforts, including participation in university-wide recruitment fairs to meet and talk with students in person, email correspondence with scholarship opportunities and information about careers in mathematics. As part of these general efforts, we pay particular attention to the recruitment and retention of URM students.

Our major recruitment effort in the Fall and Spring semesters involves an email campaign in which we target students who have performed well in their previous math courses. These email campaigns proceed as follows. We obtain data about students enrolled in our courses from our university data portal. This data includes information about a student's past mathematics history at the university, but also includes information about credit-by-exam, such as AP tests. The data we obtain also includes gender and ethnicity information about each student, and information about each student's major(s).

We collate this data to provide a report of students to contact about potentially doing a minor or double major in Mathematics or SDS. We filter the data by GPA and sort it by major. We then send out emails to the students which are customized according to their past mathematics history and their major. Our emails provide a schedule of classes to complete either a Mathematics major or an SDS major, and a couple of sentences about how such a major would complement their existing major. The email comes directly from the Director of the Math Center, Jason Aubrey, and concludes by inviting the student to schedule a meeting with him to discuss further.

Such emails are sent to all students in precalculus (Math 120R) and above who are not currently declared as Mathematics or SDS majors, and somewhere around a thousand emails are sent each semester. The response rate is fairly low, but given the volume of emails, this still often results in a substantial number of replies. Students who reply are typically interested in either a major or minor in one of our programs, so we find that this is an effective way to recruit students into our programs.

We tailor this effort for URM students in a couple of ways. First, our math GPA threshold is a bit lower for URM students than for non-URM students (2.75 vs 3.0). This is not because we believe that URM students perform less well overall, but because URM students are more likely to come from high schools with fewer resources and therefore may have come to the university with a less robust mathematical preparation. Our experience is that such students can and do succeed in our programs, though we feel that having *some* GPA cutoff is necessary to avoid recruiting students that we cannot adequately support. We look carefully at edge-cases to see if there is some history of success for these students in mathematics, and if there is really any positive indication of interest or aptitude in the mathematical sciences, then we include them in our recruitment efforts. A second way in which we tailor this effort for URM students is that we send them somewhat more personalized email messages. Often there is no additional personalization necessary, but we look more closely at these students in our data, and if we find opportunities for addressing our messages more specifically to these students then we do so.

In the late spring and summer, we also email admitted first year students, but this effort has been hampered in recent years by changes in university policies which prohibit us from directly accessing the email addresses of admitted students. We must now wait for the student to sign up for a freshman orientation session and obtain the email addresses from the orientation session rosters. As a result, this particular email campaign has proven less effective than in the past since the data is harder to obtain. We have also received negative blow-back from other units at the university worried we are trying to poach their majors, and negative blow-back from the admissions office worried we are diluting their communications and confusing students.

The Secondary Mathematics Education Program (SME-Program) also participates in recruitment efforts and collaborates closely with the advising staff and faculty from the College of Education in order to cast a wider net across both education and mathematics. Advisors from the College of Education have knowledge of the teacher preparation programs across the university and recognize the specialization of preparing teachers in secondary mathematics, therefore, they immediately refer students to the faculty director of SME-Program when students show interest in teaching mathematics at the secondary level. From 2016 – 2022, the SMEP director was the PI of a successful Noyce grant project funded by NSF that provided $10,000 scholarships for students pursuing a degree in mathematics in the education track. This Noyce grant project produced 37 undergraduate Noyce Scholars, directly addressing the shortage of teachers in mathematics. The director of SME-Program recently submitted a Noyce grant proposal to the NSF to continue providing scholarships to recruit undergraduate students into secondary education with an additional incentive to retain students in the program and in the field once they begin their teaching career, by providing a $10,000 stipend to teachers in their first year of teaching.

We also engage in a number of retention efforts. Again, these efforts are addressed at retaining all of our majors, but with specific adjustments to ensure that we are making a special effort to retain URM students:

The DATA/MATH 195M course for first-year students is intended to introduce students to the mathematical community early, helping them to meet other students in their major (since their math class may not have many – or any – other students in their major).

We have also established a peer mentoring program to aid students in their transition to the university and give them access to more advanced students in their major. In this program we pair a successful advanced mathematics or SDS student with a group of 3-5 first-year students. Our recruitment of mentors specifically focuses on URM and female students and, while participation is voluntary, we make additional efforts to encourage first-year URM and female students to participate. We have developed a mentoring curriculum focused on college survival and best-practices for success, undergraduate research, and career development. This program creates a strong feeling of community and connection among our majors which studies show increases retention.

As described below in 3d, Faculty Advising is another tool we use to aid in retention of underrepresented minority students. We have several advisors who specifically work with underrepresented students and focus extra time and attention not only on their academic success, but also on encouraging them to participate in research, internships, and other opportunities.

Since we have been attracting a larger fraction of incoming first-year majors with math placements below pre-calculus, the Math Center has adopted more aggressive advising practices for these students. Our goal is to ensure that these students are well-supported. We therefore insist that these students personally meet with an advisor early during their first semester. This allows us to better understand the student's background and goals; it also allows us to help them plan out a path to completion that takes their priorities into account. They will typically need one or two summer classes if finishing in four years is a priority. To effect this, we reach out to these students individually and place a registration hold to be removed after their advising meeting.

In the last couple of years, the Math Center has created and continues to refine a process for tracking and following up with students we are concerned about. Concerns are usually raised by an instructor (through Early Progress Reports) or advisor. The Math Center then follows up with these students to figure out how we can best support them and get them back on track.

We have also begun an effort to have discussions and gather information from students who choose to leave our majors. We plan to use this information to improve our services and look for innovative ways to increase retention, especially focusing on female, first-generation, and URM students.

Looking ahead for the next APR, we have started a pilot program to enroll incoming first-year students in cohort sections of their math classes. Again, this will give students an opportunity to meet other students who are in their major early in the program. This pilot started in Fall 2023, and we plan to continue and look at the impacts to retention.

H.12.d. Efforts to Attract and Retain Honors Students

The recruitment and retention of Honors undergraduate students is part of our overall strategy to recruit and retain students in our major programs. The table below summarizes data on students majoring in one of our programs who earned a degree in some subject with honors bestowed by the

Honors College in each year of the APR period; note that over 16% of students graduating with a major in our unit earned honors from the Honors College (in some subject).

Honors College honors	Academic Year						
Major	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Mathematics "MATH"	6	4	6	7	8	1	5
Statistics & Data Science "DATA"				1	0	1	5
Honors in "MATH/DATA"	**6**	**4**	**6**	**8**	**8**	**2**	**10**
Honors earned in another subject	16	13	13	14	12	8	15
Honors for our graduates in any subject	**22**	**17**	**19**	**22**	**20**	**10**	**25**
Total Math Department Graduates	108	106	121	145	110	102	144

^ university data (students completing honors in more than one subject are counted in each subject area)

After the last APR, the Math Center created a handout for honors college students including helpful planning information. This has been especially helpful for our Secondary Mathematics Education Program students who need to begin the thesis process a semester early in order to accommodate their semester-long student teaching field practicum internship. We have since had four SME-Program students graduate with honors; there were none on record prior to the 2016-17 Academic Year.

Three of our graduates during this APR period earned honors in Math *and* in another major (two distinct theses are required for this).

Since we do not have a wide variety of honors course offerings, we emphasize other ways to complete the honors unit requirement, especially enrollment in graduate courses for students with strong backgrounds. In our exit survey, one graduating student remarked, “I am really glad that I had the opportunity to be selective with the classes that I wanted to take and especially to enroll in graduate level courses my senior year. Compared to my experience with other departments, it is uniquely easy to do this with math classes.” The Math Center has set up a process where we facilitate approvals from the instructor and advisor for students who are interested in enrolling in 500-level courses. In the past 7 years, 79 of our majors have taken advantage of the opportunity to enroll in at least one graduate-level course in our department; six enrolled in 5 or more (and one completed 15!)

Part H.3.a. of the Undergraduate report (above) includes details on honors classes offered.

H.12.e. Undergraduate Advising

The Math Center has long been the established advising center for majors and minors in the department of mathematics. At the start of this APR period, it consisted of a full-time Program Coordinator, a newly hired Administrative Assistant (0.75 FTE), and a faculty member designated as Director of the Math

Center and Associate Head for Undergraduate Programs. In Summer 2017, we were able to hire another staff Academic Advisor. As of the end of the APR period, some personnel and titles had changed. As of Summer 2023, the Math Center Director and Associate Head positions were held by two different faculty members, the Program Coordinator is now Assistant Director of the Math Center, the Academic Advisor had been promoted to Academic Advisor II, and the Administrative Assistant was promoted to Administrative Associate (still 0.75 FTE).

Some faculty also volunteer their time to provide additional advising to our majors. These faculty advisors tend to focus more on content and selection of upper-division courses, preparation for graduate school, advice on connecting with research, jobs, and so on. While the Math Center assigns faculty advisors to most of the majors when they reach the upper-division courses in the major, our practice is to assign underrepresented minority students to faculty advisors earlier in the major to provide additional support. We have a few faculty advisors who specialize in advising these underrepresented minority students. In general, the Math Center pairs students with faculty advisors based on their major and emphasis; we also look at other majors or minors for students since many of our faculty have expertise in applications of mathematics or statistics & data science to other fields of study. The Math Center continues to maintain the internal faculty advising website established during the last APR period, including guidelines and FAQs.

While some departments assign their majors to a particular advisor based on the student's last initial, the Math Center advisors are both assigned to every student. This allows for better coverage when an advisor is out, and for times when the Assistant Director's administrative duties impact her availability to students. Advisor notes are recorded in the university's CRM (known as Trellis) and are visible to other advisors for continuity. The university CRM also offers a scheduling tool for appointments and drop-in advising availability, which the Math Center utilizes. In addition, the Math Department has our own CRM (HelpSpot) for email management and to support the Math Center's online knowledgebase. HelpSpot enables the Math Center and the Math Placement Office (and other offices within the department) to reassign tickets that are mis-directed, reply quickly to common questions with canned responses, and collaborate efficiently. Since email is the university's official means of communication with students, prompt responses to emails from students are prioritized (it is the Math Center's goal to reply to every message within one business day). The Math Center also sends out a weekly newsletter that organizes dates and deadlines, opportunities, and more into a single email message; most weeks, this is the only email sent to the entire population of majors.

Though some advising is done via email, live conversations with students are a high priority for the Math Center. Math Center staff began offering Zoom appointment options (in addition to in-person and phone) before the pandemic and transitioned relatively smoothly into remote advising in March 2020. In shifting back to mostly in-person activities, Zoom and phone appointments have continued to be offered in addition to in-person appointments. Drop-in advising is offered either in-person or in Zoom, depending on the day. Some students strongly prefer in-person meetings, but many still choose Zoom.

The Math Center has access to university data, both through a university-provided reporting tool and a departmental database which connects locally stored data with university data to keep track of our majors.

During this APR period, the Math Center has increased career preparation support for our students. Beginning in Fall 2018, workshops have been offered to help students prepare for "application season";

whether they will be applying to summer internships, Research Experiences for Undergraduates (REUs), graduate school, or something else, assistance is offered in creating/honing students' resumes/CVs and personal statements, and advice is given on how to find programs to apply to. In Spring 2020, our colloquium course, DATA/MATH 195M for incoming first-year students was offered for the first time. The colloquium, developed and taught by Academic Advisor Michelle Ort, includes an assignment to write a resume and encourages students to attend a career or internship fair to see what they are like. The Math Center has also worked to develop another course geared at Juniors, DATA/MATH 395M, but we have not been able to run it yet. The university's Office of Student Engagement and Career Development has provided helpful support and training, including their Career Champions program. More recently, the College of Science has created their own Career Office which has provided more direct support: the Director of the Center has given presentations during 195M and helped with the application workshops. We anticipate additional collaboration with them as we plan to revise the capstone course for our Data Science major.

In addition to advising, the Math Center supports many activities and events for our undergraduates. Our student-run clubs, the Math Cats (math club) and the Risk Runners (actuarial club, started in 2019), receive Math Center funding and guidance. Some of the ongoing activities include administrative support for our Undergraduate Teaching Assistant program, support for a problem-solving workshop class and Putnam competition participation, help connecting undergraduate students with research opportunities on and off campus, participation in university and college-level events, and management of departmental scholarship applications. The Math Center also recruits and funds students to attend SUnMaRC, the Southwest Undergraduate Mathematics Research Conference, each year that it runs; the Math Center planned and hosted the event on our campus in 2019.

The Math Center has also developed and coordinated a peer mentoring program for our majors. The program began in Fall 2019 with a focus on Women in STEM, though it was run by the Math Department. As of Fall 2021, the program focuses on mentoring first-year majors in our department and is no longer restricted to women. In Fall 2022, the Math Center experimented with assigning every incoming first-year student to a designated mentor, instead of having them opt-in to the program.

Some of the challenges we face with regard to advising:

- Complexity of requirements for two degrees, two majors (one with seven emphases), and three minors (expecting to have new degree next year that will also have emphases which will further complicate advising)
    - We developed an online information session for students exploring our majors to help reduce time spent describing offerings in advising appointments; we plan to revise this significantly once the new degree is approved
- Communication with students: many of them are overwhelmed by their email and some admit they do not read emails from their advisors, though email is the official means of communication with students
- Many students who need advising do not utilize the services provided.
    - The Math Center has used targeted emails and registration holds for some students so that students respond and receive additional support; these are time and labor-intensive efforts

    - To encourage faculty advisors to be proactive about working with their advisees, the Math Center established the Vélez Outstanding Faculty Advising Award in honor of William Y. Vélez, PhD, Professor Emeritus from the Department of Mathematics, and former Director of the Math Center. Dr. Vélez is well-known for the excellent mentoring and support he has provided to undergraduate advisees over the years, and the award---which includes a $1000 honorarium---is intended to recognize other faculty who provide outstanding advising in our department.
- Addition of dual degree program with CUEB: we need an additional staff member to handle issues related to the new program in China and meet the advising needs of this group of students. Currently, our Assistant Director is the primary contact for curriculum and advising-related issues, but this is not sustainable.
- Our Academic Advisor has resigned from the university; with the current hiring freeze, the replacement job requisition has been held up in HR since November 2023. This is an urgent need.

Plans for change:

- Intend to hire a Program Coordinator (most likely) to work with CUEB program and advising;
- Need to hire a new full-time advisor (Academic Advisor I) for non-CUEB students immediately;
- As of Fall 2023: Math Center has recruited Postdoctoral Research Associates to help coordinate the Peer Mentoring program and DATA/MATH 195M course to serve more students in these programs;
- Director of the Math Center will get the DATA/MATH 395M career seminar up and running in the next year;
- Once fully staffed, the Math Center intends to connect with the Advisory Board to discuss additional connections for undergraduates and the board.

H.12.f. Feedback from Graduates and Graduation Outcomes

The tables below provide data on graduates from each of our two major programs:

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Math graduates	106	106	123	135	84	69	96
Completed more than one major/degree	50.9%	42.5%	46.3%	55.6%	44.0%	46.4%	41.7%
Graduate School in Mathematical Sciences	10.4%	6.6%	3.3%	5.2%	13.1%	8.7%	11.5%
Graduate/Professional School Other	20.8%	20.8%	15.4%	23.0%	22.6%	20.3%	19.8%
Employed	18.9%	42.5%	42.3%	15.6%	26.2%	27.5%	32.3%
Employed as Middle/High School Math Teacher	3.8%	7.5%	4.9%	4.4%	7.1%	5.8%	11.5%

^ Math department records (some students are counted twice, e.g., pursuing graduate school while working

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
SDS graduates				7	26	33	49
Completed more than one major/degree				42.9%	38.5%	60.6%	34.7%
Graduate School in Stats/Data Sci				28.6%	34.6%	12.1%	26.5%
Graduate/Professional School Other				n/a	n/a	18.2%	2.0%
Employed				14.3%	42.3%	42.4%	26.5%

^ Math department records (some students are counted twice, e.g., pursuing graduate school while working. Also, SDS/Math double majors are counted in both tables.)

Some common job titles reported by our graduates include Actuary, Data Analyst/Engineer/Scientist, Financial Analyst, Software Developer/Engineer, and Systems Engineer, but we see a lot of variety.

Almost every year, we have had a graduate heading to Law School (5 of the 6 were from the math major, one from SDS); we have also had 3 graduates go on to Medical School, 1 Veterinary School, and 1 Dentistry School during this APR period.

Feedback and Reflections from Our Graduates

We have an exit survey that we ask students graduating from our major programs to complete. Comments solicited by that survey over the APR period include the following feedback:

- Overall, there is appreciation for the positive aspects of the program, with some students expressing gratitude for advisors, instructors, and the department's inclusivity.
- Class Structure and Teacher Appreciation:
    - Some students suggest that class time should be used for collaborative work with teacher assistance rather than traditional lectures.
    - Positive feedback is given for Dr. Adi and the setup of his classroom.
- Freedom and Flexibility:
    - Students appreciate the freedom and flexibility within the math department, allowing them to explore their interests.
- Career Preparation:
    - Students express the desire for more exposure to real-world applications of mathematics in various fields, including actuarial work and industry applications.
    - Some mention the need for better understanding of how the learned concepts apply to future careers.
- Specialized Classes and Topics:
    - Enjoyment of specialized classes such as cryptography, graph theory, and interest in more classes in areas like game theory.
    - Requests for more undergraduate-level courses in number theory and exposure to theoretical, proof-oriented aspects of mathematics.
    - Some wish for exposure to financial mathematics and more diverse applications of math in biology.

- Preparation and Challenges:
    - Some students feel unprepared for certain higher-level courses, and the challenges of remote learning during the COVID-19 pandemic are mentioned.
- Appreciation and Positive Experiences:
    - Overall, many students express gratitude for the education received, highlighting the support from the Math Education Program, caring professors, and flexibility in course selection.
    - Students express gratitude for the intelligence and talent of professors and teaching assistants.
    - Dr. Veléz is credited for guiding students and fostering a love for statistics.
    - Some students appreciate the program's organization, easy class scheduling, and informative Math Center emails.
    - Enjoyment of specific courses is highlighted, and some students had positive experiences with instructors.
    - The accommodating nature of the math department towards transfer students is acknowledged.
- Areas for Improvement/Constructive Criticism:
    - Requests for a more comprehensive review of learned concepts and exposure to various mathematical tools and software.
    - Desire for more opportunities for research, exposure to advanced topics, and balance between pure and applied mathematics.
    - A call for more opportunities for undergraduate research and an easier way for students to connect with professors seeking research assistants.
    - Recommendations for a more consistent curriculum and a balance between theory and practical application.
    - Some students wish for a greater balance between pure and applied mathematicians among the faculty.
    - Suggestions for a wider range of courses, earlier exposure to proof writing, and more application-based courses.
    - Some students find that the emphasis on theory and proofs is excessive, especially for those pursuing careers outside of research fields.
    - There is a call for increased emphasis on programming fundamentals, particularly for those in data science.
    - Requests for more exposure to coding, particularly in languages like MATLAB, Python, and SQL.
    - Some students express the desire for courses on numerical linear algebra and more integration of programming with math concepts.
    - Suggestions are made for a more practical approach, including more application-focused courses in statistics and probability.
    - Concerns are raised about the difficulty of certain courses, particularly during the pandemic.
    - Requests for more consistent teaching across the department, especially in terms of content coverage, are made.

    - Some students express a desire for more support in interview preparation and increased exposure to Python programming.
- Mixed Opinions:
    - Some students had a 50/50 experience, with some faculty being supportive and others appearing less empathetic, especially towards older students returning to mathematics.
    - A discrepancy is noted between the expectation of a data science degree and the actual emphasis on statistics.

H.13. Undergraduate Program Learning Outcomes Assessment

Mathematics Major BA/BS assessment:
2022-23 http://www.math.arizona.edu/files/APR2024/BSBAMath2022-2023.pdf
pre-2022 http://www.math.arizona.edu/files/APR2024/BSBAMathpre2022.pdf

Statistics & Data Science Major BA/BS assessment:
2022-23 http://www.math.arizona.edu/files/APR2024/BSBASDS2022-2023.pdf
pre-2022 http://www.math.arizona.edu/files/APR2024/BSBASDSpre2022.pdf

Assessment of student learning outcomes has enabled us to reflect on our academic offerings in light of our agreed upon learning outcomes. By having a conversation about our goals for students in our programs, we have been able to crystallize what we think is important about a degree in mathematics. This in turn has enabled us to think in a new way about our current and new course offerings, and to design or re-design courses to ensure that our learning outcomes are being emphasized and assessed in our courses.

In addition, our current assessment efforts combine both instructor assessments of student achievement on our learning outcomes, and student self-assessment via an exit survey given to graduating students. This has provided an interesting comparison of how instructors view student achievement on our learning outcomes versus how students view their own level of achievement on those outcomes. Interestingly, the results have largely been consistent between the two measures, providing us with some additional confidence that our results accurately reflect student achievement.

Our process of assessment has not so far included any breakdown of results by student demographics, or program modality. Our Undergraduate Committee is the body tasked with oversight of our annual assessment process, and we will explore options for this with our undergraduate committee. This will require either modifying our existing measurements, or introducing new measurements which include student demographics and program modality.

I. GRADUATE STUDENTS, DEGREE PROGRAMS AND OUTCOMES

I.1. Graduate Program Overview

The Department offers PhD degrees in Mathematics (with specializations in mathematics and mathematics education), MS and MA degrees in Mathematics, and an MA with Teaching Option degree. The department is also about to begin offering an accelerated masters in Statistics and Data Science. The department offers a PhD minor in Mathematics. The CIP code for the programs are 27.0101.

During the current APR period, the Department has granted 48 PhD degrees and 19 MS degrees. The graduating students entered a number of different types of positions, including postdoctoral positions, tenure track positions right out of PhD, and nonacademic positions, as seen at https://www.math.arizona.edu/files/APR2024/FirstJobPhD.pdf .

Significantly more PhD graduates have been going into nonacademic positions than in the previous APR period. In response to this, the program has recently made a significant change to its professional development requirement. While the previous requirements included courses outside mathematics, programming, language, and/or communication, the revised requirement places an emphasis on self-determined learning at multiple levels, leadership, communication, programming, and broadening participation. A more flexible set of professional development options together with a yearly expectation sets the tone for professional development as an ongoing part of one's career instead of some requirements that are satisfied once.

Another major change has been a more common use of a Master's Thesis for a qualifying exam for PhD students. While the qualifying exam/core class structure is very traditional, with each student taking Abstract Algebra, Real Analysis, and Geometry/Topology, the master's thesis exam allows students to pursue another field for a qualifying exam and also gives them an alternative to a timed exam. While this option is not new during this APR, the use of it during the early planning stages of a student's time has been applied more aggressively. With the current structure of the PhD program, including a research training experience in Fall of the second year, all students are in a position to complete a master's thesis during their third year.

Another major change has been not requiring a GRE for admissions to the program. During the COVID-19 pandemic, it became difficult to take the GRE. In successive years, most graduate programs have removed the requirement of the GRE for admissions, and we have followed suit in order to stay competitive. In order to compensate, we have begun doing more zoom interviews of students prior to making acceptance offers. A new system is being piloted in the 2024 cycle that ties the interviews more closely to review criteria.

Additional changes were made to major milestones in our program, the Integration Workshop, and the Research Tutorial Group (RTG). The Integration Workshop is a five-day workshop for incoming students to get to know their cohort and to be introduced to the graduate perspective on mathematics. Previously, the workshop had consisted of three courses of 3-hour blocks each, one on linear algebra, one on real analysis, and one on point set topology. More recently, we have restructured the workshop to touch on most elements of the undergraduate major: calculus/multivariate calculus, linear algebra, real analysis, abstract algebra, complex analysis, point set topology. There were several reasons for the change. First, there were some students who had not taken topology or had less of the other classes,

and the new format allows us to start with mathematics that all students will have seen. It also allows us to emphasize some of the mathematics from earlier classes that is essential to success in the core graduate classes; some of the instructors noticed that some students needed practice in these, for instance Taylor series. For two years we were able to expand the student experience by including students from Applied Math in some of the courses. However, this past year the workshop was back to Math students only.

The RTG is a series of two classes in the spring of first year and fall of second year meant to introduce students to research. The first course is a seminar where faculty discuss their research areas. The second course is a research training experience, which may consist of research work, or the type of training needed to do research. This course is meant to be limited to one semester and to involve individual or group work in order to learn and practice techniques needed for research. Previously, the first course would consist of three to four lectures by a faculty member or team discussing potential research problems for the second course, although the students were free to choose faculty who did not lecture. The new format allows students to get a more panoramic view of the research done in the department. Also, previously there was an emphasis on research in the second course; the new model is based on comments from faculty that sometimes doing research at the level of a beginning second year student is not the best way to prepare for doing dissertation level research in fields that are very deep. For this reason, we have expanded the notion of research training to allow for differences between fields. Exit interviews have been very positive on this change.

I.1.a Graduate Students

Students are recruited through several means, including mailing/emailing posters to mathematics departments, attending AMS Graduate Fairs, attending the Math Alliance Career Fair, and maintaining a website with information on the programs. We get many students recommended by former students and postdocs from the department. We have just started collecting information about how students learn about our program and will have additional information on this during the next cycle. Since GREs are generally not required and GPAs are generally inconsistent, we have been unable to compare the quality of students we are recruiting from other institutions. We did compare our recruitment strategies to those reported in the TPSE/Rutgers report on Career Preparation in Math Graduate Programs 2021 Survey and Interview Project. We use all the strategies listed except department social media (on average, considered 6.8th most effective method), directly reaching out to HBCU or MSI institutions (on average, considered 7.2nd most effective method), and international math conferences (on average, considered 8.2nd most effective method).

Top students are nominated for University Fellow awards, a competitive award for incoming students across the university that provides a high fellowship without teaching for the first year and builds a leadership cohort. We have had two students participate in this program during the last APR cycle, and consistently try to use this mechanism to attract top students. For students who are first generation college students or who have experienced hardship, Graduate Access Fellowship awards can provide additional funding in the first year. The department is also able to provide some partial fellowships to students through funds supplied by the graduate college or by the department itself. The department also extends offers of summer support for the first summer to most students. In recent years, the program has also been able to recruit some students to be supported on a traineeship grant (NSF RTG) for the first year to eliminate the need for a TA-ship in that year.

Admissions rates can be seen in the table below, showing the average number of admissions divided by the number of applications, and then the average percentage of students accepting among those admitted. Note that admissions for Fall 2020, during the initial period of the pandemic, were cut short before the April 15 deadline by the university, who asked us to rescind all offers made for financial aid and not accept any more students. This accounts for the unusual numbers from that year.

Admit term	Average of Admissions per Applications	Average of Acceptances per Admissions
Fall 2017	**50%**	**27%**
Fall 2018	**49%**	**34%**
Fall 2019	**47%**	**36%**
Fall 2020	**29%**	**16%**
Fall 2021	**43%**	**40%**
Fall 2022	**45%**	**26%**
Fall 2023	**44%**	**34%**
Grand Total	**44%**	**31%**

Note that Fall 2020 is an aberration since the university required all departments to rescind their unaccepted offers one week before the deadline. The number of students accepted has been fairly consistent, though the rate of acceptance of these offers varies widely from year to year, between 26% and 40%. It is not clear what the difference is between these years.

Alarmingly, the acceptance rate for female applicants has declined significantly, even though the admission rates higher than that for male applicants each year. One result has been a sharp reduction in the number of female graduate students in the last two entering classes. In the last two years, an effort was made to provide the highest possible financial aid to potential female students and to make offers early. Surveys of students who declined admission in 2023 indicate that 86% accepted an offer with a better research fit, 46% said the salary offer is too low, 30% said another geographic location was more desirable, and 15% said there were concerns about diversity or selected a program with more diversity. However, 2 of the 3 women who responded said there were concerns about diversity or selected a program with more diversity. Since it is difficult to build diversity directly, we plan to focus attention on new methods to advise students in inclusive ways and to build structures that are welcoming. The hope is that these new structures will create a welcoming community that will encourage more women and students from underrepresented groups to choose University of Arizona.

	Average of Admission Offers/ Applications	Average of Enrollments/ Admission Offers	Number of Applications	Number of Admissions offers	Number of Students Enrolled
Female	**52%**	**28%**	**124**	**64**	**18**
Fall 2017	50%	33%	18	9	3
Fall 2018	71%	33%	17	12	4
Fall 2019	53%	22%	17	9	2
Fall 2020	37%	14%	19	7	1
Fall 2021	56%	50%	18	10	5
Fall 2022	50%	18%	22	11	2
Fall 2023	46%	17%	13	6	1
Male	**41%**	**32%**	**434**	**180**	**62**
Fall 2017	50%	25%	48	24	6
Fall 2018	43%	34%	67	29	12
Fall 2019	44%	42%	43	19	10
Fall 2020	27%	17%	66	18	3
Fall 2021	40%	36%	63	25	9
Fall 2022	45%	28%	87	39	12
Fall 2023	43%	38%	60	26	10
Not Reported	**0%**		**1**	**0**	**0**
Fall 2022	0%		1	0	0
Grand Total	**44%**	**31%**	**559**	**244**	**80**

The table below summarizes gender and race/ethnicity composition of current graduate students with majors in Mathematics. A similar table for each year of the APR can be found at https://www.math.arizona.edu/files/APR2024/Demographics.pdf . As a comparison, the American Mathematical Society (AMS) reports that Math Public Medium institutions (which University of Arizona is one) reported 28% female, 51% non-US student composition in its most recent report, Fall 2018. The AMS also reported that math programs had 14% underrepresented minority students in the same year. Thus, we see that the program has a higher percentage of US students compared to comparable programs.

Gender	Asian	Hispanic	Non-US	Unknown / Other	White	Grand Total	Percentage
Female	2	2	2		5	11	19%
Male	4	2	15	1	24	46	81%
Grand Total	**6**	**4**	**17**	**1**	**29**	**57**	
%	**9.8%**	**9.8%**	**29.5%**	**1.6%**	**49.2%**		

The department is a silver member of the Math Alliance, regularly attends the Math Alliance Field of Dreams conference, and works to recruit minority students through the Grad Fair and networking at the conference. The conference sends contact information for attendees and an effort is made to reach out to these students. The Graduate College offers application fee waivers for members of the Math Alliance, SACNAS, McNair, and other organizations that promote diversity. These are all published in the recruiting materials (posters and emails) sent to schools. The DGS is the Principal Investigator on a collaborative planning grant funded by NSF working to recruit diverse students and plans to submit an inter-institutional collaborative proposal together with UC Merced, UT Rio Grande Valley, and UT San Antonio to recruit low-income students to study at Mathematical Sciences programs at these schools.

The table below shows the minimum salaries for Graduate Assistants during this APR period. For comparison, Texas A&M is $24,600, Minnesota is $22,000, and Rutgers and UC Davis are at least $30,000 according to American Mathematical Society (AMS) website. Students get a small raise when they complete qualifying exam and a small raise when they complete comprehensive exam. Within the college, the 2023 is the same as Computer Science and Physics, though lower than Chemistry/Biochemistry ($29,000) and Ecology & Evolutionary Biology ($23,000).

Year	Minimum Salary
2016	$18,000
2017	$18,000
2018	$18,900
2019	$18,900
2020	$18,900
2021	$18,900
2022	$20,000
2023	$21,750
2024 (projected)	$22,400

As can be seen in the following table, most of our students are offered assistantships. In certain years, for instance 2023, the number of assistantships is lower due to other forms of support, including Traineeships sponsored by an NSF RTG grant and Graduate Outreach Scholars who are supported by donations and funded as cash stipends plus tuition scholarships.

Fiscal Year	Enrolled Grad Students	Assistantships	Enrolled Grad Students with Assistantship
2017	54	50	93%
2018	56	48	86%
2019	60	50	83%
2020	58	50	86%
2021	48	43	90%
2022	50	47	94%
2023	55	48	87%

The stipend amount has generally been sufficient for students to afford a shared apartment and general living expenses. However, with increasing rents and more students with families, students report increasing difficulties in finding affordable housing and paying their bills. The department has worked hard to provide additional opportunities for scholarships for students, including the department's Grogan award ($6,000 to two students per year). Some of our students have been successfully nominated for college and university awards as well, including the Robin fellowship ($8,000 per year for four years) and the Likins fellowship ($10,000), which are specifically designed to target students with financial hardship. The department has been able to support some travel of students to conferences through an endowed fund. Also, the department is a member of SL-Math (formerly Mathematical Science Research Institute), and through that project sends 2-4 students from the Math and/or Applied Math and Statistics & Data Science programs to summer workshops each year.

We have 56 Math Graduate Students and 48 Graduate Faculty, giving a ratio of 1.17 students/faculty member. However, a large number of our faculty advise PhD students in other programs, most notably the Graduate Interdisciplinary Programs in Applied Math and in Statistics & Data Science. If one includes the students from those programs with advisors in the Mathematics Department, the ratio is 1.79 students/faculty member. As a brief comparison, the ratio for Mathematics at Texas A&M is 1.0 and the ratio for Mathematics at Minnesota is 1.41. The report from the last APR suggested that a ratio of 2 is more sustainable for research, but we have not seen evidence for this number.

Student mentoring is a collection of a major professor/advisor, teaching mentor/supervisor, and the Director of Graduate Studies (DGS). All students are asked to choose a major professor during the first year or are assigned one if they do not have a preference. This professor can be changed at any time and the role is replaced by the research advisor when one is selected. Teaching mentor/supervisors are assigned to teaching assistants (TAs) each semester and provide guidance and oversight on teaching activities. The DGS meets at least twice per year with students who do not have a research advisor in order to advise on course selection, qualifying exams, and other issues that arise in the course of their

studies. The DGS also reaches out to students who are close to graduating to discuss career plans and goals.

Oversight of the student takes place at different places. For TAs, a Career Conversation is solicited and filled out together with the teaching mentor/supervisor. For RAs, a Career Conversation is solicited and filled out with the advisor or research mentor. First year students have a mini–Individual Development Plan for the summer that is discussed with the DGS prior to the summer. Professional Development activities are reviewed with the major professor/advisor at the beginning and middle of the year and reported to the graduate office. Students also fill out a yearly survey that goes to the Graduate Office and is reviewed by the Graduate Coordinator and DGS.

There are some new methods we have used recently or plan to use in the near future. During Fall 2023 and Spring 2024 we have instituted a mentor for first year students. The Mentor meets several times during the semester to help the students determine their understanding of course material and assess their approach to learning mathematics. The Mentor is not the DGS or a teacher of the core classes, and so is able to give an outside perspective. In addition, we are planning a more careful Individual Development Plan (IDP) that incorporates the professional development requirements as well as career guidance and planning. Rough drafts of these have been written based on IDPs from Stanford Health Sciences.

One of the main comments from graduates is that they did not consider career choices early enough. As part of the new professional development requirements and IDPs, we are able to encourage students to participate in professional development activities available at the Graduate Center and other places to begin thinking about career goals earlier. We have also begun working with an Industry Advisor Board of alumni and affiliates to help give timely and accurate information about non-academic jobs. The first event in Fall 2023 was widely attended by PhD students in Math.

While it is difficult to do a complete survey of conference presentations and publications, we have included a partial list at https://www.math.arizona.edu/files/APR2024/Talks.pdf and https://www.math.arizona.edu/files/APR2024/Publications.pdf . This contains 26 individual students with 155 total talks, and 21 individual students with 58 publications and preprints. We have an endowed fund for travel that helps support around 2 or 3 students per year to attend conferences, and sometimes are able to provide additional funds if they are not supported by the conference or their advisor. There is a university source of funding through the Graduate and Professional Association (GPSA), however students have not been very successful at attaining funding through this source recently due to how competitive the funding is.

The following table shows the time to degree for students completing a PhD in Mathematics 2017-2023, as drawn from University of Arizona analytics. It is notable that students who finish in the summer after their 6^{th} year are considered a time 6.5, as are students who finish in the fall after their 6^{th} year, which explains why many times to degree are above 6. For 2019, there is a single student who took a long time to graduate that skews the average for that year.

	2017	2018	2019	2020	2021	2022	2023
PhDs Awarded	7	6	9	5	8	3	6
Average Time to PhD Completion	6	6.08	6.94	6.2	6.5	5.67	5.58
Median Time to PhD Completion	6	6	6.5	6	6.25	6	5.75

The following table gives the number of MS degrees awarded and average time to completion. Many MS degrees start while the student is in a PhD program, so the average time to degree reflects that many students are in this program for only a short time. Note that no MA degrees were conferred during this APR period.

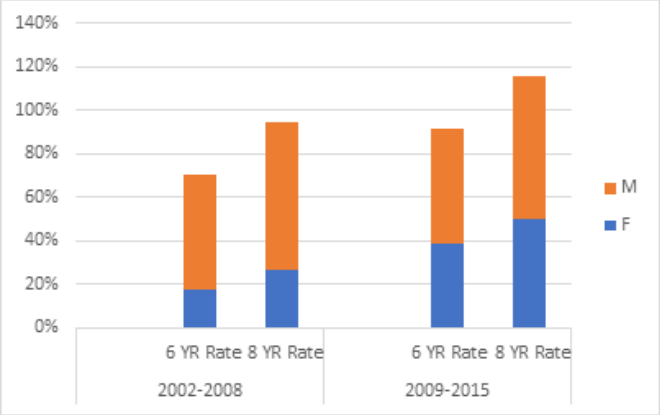
	2017	2018	2019	2020	2021	2022	2023
MS Degrees Awarded	2	1	1	4	5	4	4
Average Time to MS Completion	1.25	0.5	0.5	1.5	1.8	0.5	0.75
Median Time to MS Completion	1.25	0.5	0.5	1.5	1	0.5	0.75

The table on the following page gives the 6-year, 8 year, and 10-year completion rates and number of students completing who entered 2002-2015, grouped by APR period and year.

Year Entered	6 YR Completion Rate	8 YR Completion Rate	10 YR Completion Rate	Number of students
2002-2008	**41%**	**54%**	**56%**	**70**
Fall 2002	33%	33%	33%	6
Fall 2003	25%	75%	75%	8
Fall 2004	30%	40%	40%	10
Fall 2005	30%	40%	40%	10
Fall 2006	69%	77%	85%	13
Fall 2007	50%	50%	50%	14
Fall 2008	33%	56%	56%	9
2009-2015	**49%**	**62%**	**66%**	**73**
Fall 2009	50%	50%	50%	12
Fall 2010	53%	67%	73%	15
Fall 2011	38%	50%	50%	8
Fall 2012	55%	100%	100%	11
Fall 2013	40%	50%	50%	10
Fall 2014	38%	38%		8
Fall 2015	67%	67%		9
Grand Total	**45%**	**58%**	**60%**	**143**

We have shown great improvement since the last APR on completion rates. In addition, we have shown great improvement on the completion rates for female students compared to the last APR period. The following shows the breakdown of completion rates by Female/Male. Note that according to a Counsel of Graduate Schools report (PH.D. COMPLETION AND ATTRITION: Analysis of Baseline Demographic Data from the Ph.D. Completion Project, 2008) Math & Physical Sciences has a ten-year completion rate of 52% for women and 59% for men.

	Completion Rates		
Year Entered	**F**	**M**	**Grand Total**
2002-2008			
6 YR Rate	17%	53%	41%
8 YR Rate	26%	68%	54%
2009-2015			
6 YR Rate	39%	53%	49%
8 YR Rate	50%	65%	62%



Graduation rates also improved over American Indian and Hispanic/Latinx. It is notable that while 4 black students were recruited during the previous period, none completed in eight years. During this period, no black students were successfully recruited. The program will continue to work to recruit more students from diverse backgrounds including race/ethnicity.

	American Indian or Alaska Native		Asian		Black or African American		Hispanic or Latinx		International		Not reported		White	
Entrance Years	8 Year Rate	Count	8 Year Rate	Count	8 Year Rate	Count	8 Year Rate	Count	8 Year Rate	Count	8 Year Rate	Count	8 Year Rate	Count
2002-2008	0%	1	33%	3	0%	4	0%	4	78%	18	60%	5	57%	35
2009-2015	100%	2	75%	3			75%	3	65%	17	50%	1	57%	38
Grand Total	67%	3	57%	6	0%	4	38%	7	71%	35	57%	6	57%	73

In an effort to increase retention, the program has been piloting having a dedicated faculty mentor for first year students during 2023-2024. The mentor helps students identify stress points in their first year of study by regularly meeting with the students and having them present homework problems or other math to gauge understanding and progress. A student success class for first year students is planned to be piloted in the fall. The program will continue to run its Research Tutorial Group program, which introduces students to research in years 1-2, helping students successfully progress from coursework to research. Many students were negatively impacted by the pandemic, and extension of deadlines has been considered and often granted on a case-by-case basis in order to allow them enough time to complete their requirements.

The DGS also received an NSF S-STEM planning grant to plan an inter-institutional consortium, to be submitted March 2024. The project is dedicated to systematizing institutional support structures, including mentor training and the summer bridge program, collaborating with the UArizona Mentor Institute and Project Adelante's summer bridge program for undergrads. These are two highly successful projects currently running at UArizona. The project will also work on building community first within school, and later across the different schools (UC Merced, UTexas Rio Grande Valley, UTexas San Antonio).

A list of graduate student placements since the last APR is listed at https://www.math.arizona.edu/files/APR2024/FirstJobPhD.pdf . During this period, 35% of graduates attained a nonacademic job and of the 10% without offers, most were actively seeking a nonacademic job. In addition, at least 9 of the 26 students who went into education have since left for nonacademic positions. Keeping these in mind, the actual percentage of PhD graduates who went into nonacademic jobs within 4 years of completing their degree is almost 65%. From discussion with alumni, important skills for transition to industry include communication and programming skills. Communication may mean presentations, written work, interpersonal communication, and working with a team. One of our first steps toward cultivating these skills is the recent implementation of new professional development requirements. These requirements reward leadership and communication with peers and others, as well as encourage a thoughtful exploration of professional development as a regular part of one's job training.

I.1.b Graduate Student Learning Outcomes Assessment

The reports on assessment for PhD and MS/MA programs can be found at:

https://www.math.arizona.edu/files/APR2024/PhDAssessment.pdf
https://www.math.arizona.edu/files/APR2024/MSAssessment.pdf.

The general reports find that we are mostly meeting our expectations for learning outcomes as described. Difficulty in the program thus is a result of students' higher expectations not being reflected in the learning outcomes measured. Review of the learning outcomes for the program is due in order to better reflect and communicate the values and goals of the program. Graduation rates for most demographics have improved in this APR period. One of the main challenges ahead is the recruitment of students with diverse backgrounds and continued work to identify challenges to students, taking into account intersectionality. While graduation rates have greatly improved, there is room for improvement. The program is currently discussing how to enforce requirements earlier in the program and how to provide appropriate interventions for students who are not meeting expectations. An important part of this is communication of expectations in the program, which is also under discussion.

Given the large number of students entering nonacademic careers, outcomes such as communication become even more important. In order to promote multiple career pathways, the program has revised its professional development requirements to allow for many opportunities to develop skills such as communication, leadership, organization, computing, and others. The new requirement is meant to teach that professional development is an ongoing piece of one's career and should be considered every year instead of as a one-time requirement. In addition, the department is developing closer ties with alumni and other department affiliates in nonacademic careers to help communicate the interest and mechanism for such careers outside academia. Part of this initiative is the creation of an Industry Advisory Board (IAB) consisting of alumni and departmental affiliates in nonacademic positions. The first IAB event in October 2023 attracted many undergraduate and graduate students. During the event, members of the IAB helped with networking, writing resumes, interviewing, and gave lots of information about careers. Many of these connections have lasted beyond the workshop into the job application process. In addition, the department maintains a LinkedIn site and connects with alumni through this mechanism.

I.1.c Curriculum and Courses

We do not have multiple sections of any graduate courses, except for the case of special topics classes, which have different requirements and hence different outcomes. As seen in the table below, graduate courses are well-balanced between academic disciplines, with the exception of Mathematics Education, whose classes have run less frequently. If one considers Algebra and Number Theory together with Geometry/Topology, then this balances well with Analysis, Applied Math, and Probability/Statistics.

Field of Math	Number of times taught	Average Enrollment
Algebra and Number Theory	41	8.3
Analysis	68	8.9
Applied Math	69	11.2

Geometry/Topology	29	8.2
Math Ed	8	10.5
Prob/Stat	69	9.1
Grand Total	**284**	**9.33**

While the majority of our graduate courses are traditional lectures, we have had some faculty experiments with flipped classrooms or other active learning techniques. As a program, we encourage projects at two major stages. Immediately prior to entering the program students participate in an Integration Workshop (IW), which is a 5-day workshop where students cover some undergraduate mathematics from a graduate perspective. An important part of IW is presenting solutions to problems at the board, and also a major group project. During the Fall of each student's second year, they participate in a Research Tutorial Group (RTG) project. The project is a one-semester research training experience that allows them to work toward research either individually with an advisor or in a group setting. RTG students present their work in a mini conference at the end of the fall semester.

It is typical for classes to use D2L in classes. Zoom and Panopto are occasionally used. We do not currently have any intention of offering online classes.

Graduate students have shared office space, the majority of which is in an open office layout in the ENR2 building. There is photocopying available and basic office supplies are available in the main office in the Math building.

University resources include campus health, counseling, disabilities resource center, work and life connections, and the campus pantry. Counseling at CAPS (Counseling and Psychological Services) is free to graduate students in the College of Science; in the last two years the college has agreed to pay for the out-of-pocket costs for these students. The DRC (disabilities resource center) provides help for students with learning disabilities and other disabilities. For instance, students may get additional time or have a quieter environment for qualifying exams; this has been used a number of times by our students. We had one deaf student who completed a PhD recently; DRC was able to provide interpreters for classes, seminars, and important meetings. One current student with disabilities has been working with DRC for resources including a transcriber. DRC services are also available for qualifying exams.

The following tables show the PhD minors of Math PhD Major students 2016-2023 and the number of students with a PhD minor in Math and their corresponding majors. It is notable that more than 50% of all math minors are not from Mathematics, and that these students come from all across the university, including six different colleges. Math PhD students tend to minor in Math, though we do get a significant number who have minored in Statistics and sometimes other subjects. Many students choose to get certificates, e.g., in Teaching or Statistics, rather than minor in these subjects. Part of the reason is that it is difficult to change a minor later in their program, since the comprehensive exam must have a member of the minor program, and some students have not decided on a minor outside of math by the time they take the exam in the third or fourth year. Certificates tend to have a similar requirement as a minor, but do not have this restriction.

Minors of Math PhD Majors		
Top Minors	**Number**	**Percentage**
Mathematics	27	66%
Statistics	7	17%
Applied Math	2	5%
Computer Science	2	5%
Philosophy	1	2%
Physics	1	2%
Teaching & Teacher Education	1	2%
Total	**41**	

Minors in Math		
Top Majors	**Number**	**Percentage**
Mathematics	27	46%
Electrical & Computer Engr	13	22%
Aerospace Engineering	3	5%
Computer Science	3	5%
Physics	3	5%
Teaching & Teacher Education	3	5%
Optical Sciences	2	3%
Ecology & Evolutionary Biology	1	2%
Economics	1	2%
Information	1	2%
Mechanical Engineering	1	2%
Statistics	1	2%
Total	**59**	

The Graduate Student Handbook can be found at
https://www.math.arizona.edu/files/grad/HandbookMath.pdf

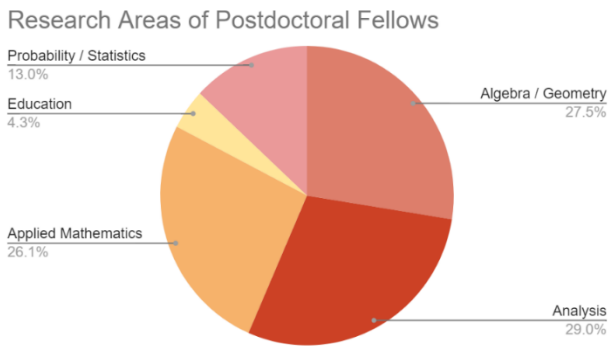
I.2. Postdoctoral Scholars, Professional Development and Outcomes

The department has a unique and innovative postdoctoral program, whose mission is to guide junior researchers on the path toward a successful and fulfilling STEM career. The program was started in 2016 by combining existing departmental resources with new funding that the College of Science provided as a result of the previous APR. A new position, Coordinator of the Postdoctoral Mentoring Program, was created, with the charge of developing a program. A Postdoctoral Committee, consisting of 4 elected tenured or tenure track faculty and chaired by the program coordinator, was formed in 2018. In 2019, as the program became more established, the coordinator position received an associate head designation. Both positions have been held so far by Joceline Lega.

Currently, the program has 15 regular postdoctoral lines, including 2 named postdocs. Postdocs are considered to be junior faculty and engage in the teaching, service, and research activities of the department, with a minimum research workload of 50%. Their regular teaching load has been 3 undergraduate courses per year, including upper-division and special topics courses; named postdocs have a reduced load of 1 course per semester. Those partially supported on grants teach one or two courses per year. As of Spring 2024, the teaching load of regular postdocs changed to 7 units per year (most undergraduate courses are 3- or 4-unit courses). The corresponding 5% teaching load reduction, from 40% to 35%, was accompanied by an increase in service load, from 10% to 15%. Such an adjustment gives us the opportunity to better quantify and recognize the many service contributions that postdocs already make to our department. Our postdoctoral contracts are for 3 years, renewable each year, with the possibility of an extension to a fourth year. Some postdocs leave during their first or second year, to move on to more permanent or more lucrative positions.

The program is run by the Associate Head for Postdoctoral Programs with assistance from the 3-person administrative team that also supports the Head's office. The Postdoctoral Committee is involved in all decision-making aspects of the program, including hiring, travel and summer funding for postdocs, annual performance review, and program policies. The Associate Head chairs the Postdoctoral Committee, conducts entry, and exit interviews, holds individual on-demand meetings with postdocs, and stays in contact with the postdoc group through her weekly participation in the professional development seminar.

All our postdocs have a tenured or tenure-track faculty mentor with expertise in their research area. The chart below shows that since the inception of the program, postdoc positions have been roughly equally distributed between algebra & geometry, analysis, and applied mathematics, with fewer positions in mathematics education and statistics (two areas which often recruit fresh PhDs into tenure track positions). The program provides a range of growth-promoting activities, including a weekly professional development seminar. To strengthen the cohesion of the postdoc group, we have put in place a governance structure that includes a postdoc president, a vice-president, a social representative, a teaching representative, as well as representatives to the undergraduate and climate, diversity, equity, and inclusion committees. The President of the postdoc group is the official liaison between the postdocs and the program administration. In consultation with the associate head and with assistance from the Vice-President, they also organize the professional development seminar.



As detailed in the paragraphs below, the program has been successful in providing postdocs a supportive and growth-promoting environment, leading to good placement at the end of the training period. Postdocs bring a significant amount of energy to the department and are engaged in co-running many of our seminars, in outreach activities such as our Math Circle, or in creating special topics courses for our majors. We have been able to recruit strong applicants and will continue to promote the program through our website and presence at the JMM. We are also looking into increasing the number of named postdocs through donations. As the number of program alumni grows, word of mouth will also be useful.

The program has received a range of accolades from the university: 2024 Outstanding Postdoctoral Scholar Award (Alison Mirin) and Honorable Mention (Darlayne Addabbo), 2023 Outstanding Postdoctoral Scholar Award (Christian Parkinson), 2020 Outstanding Postdoctoral Scholar Award (Rachel Neville), 2019 Excellence in Postdoctoral Mentoring Award (Joceline Lega). In addition, our postdocs have successfully received competitive grants: AMS-Simons travel grant (Hossam Abdul-Rahman, Darlayne Addabbo, Jeremy Booher, Paul Carter, Minh Kha, Yong-Suk Moon, Tracy Stepien, Weinan Wang, Pan Yan, Amanda Young), NSF (Paul Carter; May 2018, $90,837.00. Faryad Sahneh; April 2020 $156,424.00), and AOR (Keaton Hamm; September 2018, $48,633).

Despite this success, the financial crisis the University of Arizona is experiencing will prevent us from replacing departing postdocs in 2024, potentially reducing the program size by 1/3. Such a drastic cut jeopardizes the program's survival. Indeed, we estimate that 20 lines are necessary to guarantee long-term stability: to preserve the synergy between postdocs and to maintain the program’s ability to transform and evolve with the discipline, slightly exceeding the critical mass threshold of 5 new postdocs per year is essential. Funding from training grants supported by the NSF TRIPODS and RTG programs has been beneficial but is short term in nature.

I.2.a. Recruitment

We recruit fresh PhDs as well as second postdocs from a range of research-intensive universities.

In the past 5 years, the PhD or postdoctoral institutions of our entering postdocs were Arizona State, Brigham Young (2), Carnegie Mellon, Claremont Graduate University, Duke, Louisiana State, Iowa State, Montana State, Northeastern, Northwestern (2), Ohio State, Purdue, SUNY Buffalo, U. Claude Bernard Lyon, UC Irvine (2), UCLA, UC Merced (2), U. Colorado Boulder, U. of Georgia, UMBC, U. of Illinois at Urbana-Champaign, U. of Indiana Bloomington, U. of North Carolina, U. of Missouri-Columbia, U. of Southern California, U. of Toronto (2).

We receive several hundreds of applications through Mathjobs every year. These are reviewed by members of the Postdoctoral Committee and the faculty to create a shortlist of applicants with potential mentors. A subsection of this latter group is selected for a Zoom interview, conducted by a 3-person panel, which includes the potential mentor, a representative of the teaching mission of the department, and a member of the Postdoctoral Committee. Historically, a third to half of our offers are accepted. We lose candidates to NSF postdoctoral fellowships, more research-intensive postdoctoral positions, or to better paid positions. The table below summarizes our recruitment process for the last 5 years.

Academic Year	Number of applicants	Number shortlisted	Number interviewed	Number of offers made	Number of offers accepted
2019-20	350+	50	23	17	7
2020-21	350+	62	30	8	5
2021-22	~450	39	20	11	7
2022-23	350+	36	22	20	6
2023-24	~300	79	29	16	6

I.2.b. Gender and Race/Ethnicity Composition

The percentages in the table below, provided by the university, are based on totals that are slightly different from our records for the program, since not all postdoctoral positions include the word "postdoc" in their official title. However, the overall gender balance (about 35% female) is consistent with our numbers. We note that this is higher than the typical percentage of doctoral degrees awarded to women in Mathematics and statistics, which was 29.6% in 2019 (State of the US S&E Indicators 2022, https://ncses.nsf.gov/pubs/nsb20223/demographic-attributes-of-s-e-degree-recipients). We exceed the gender balance among postdoctoral fellows in mathematics and statistics, which in 2021 was 74.9% male and 25.1% female, according to Table 4-10b of the Survey of Graduate Students and Postdoctorates in Science and Engineering (https://ncses.nsf.gov/surveys/graduate-students-postdoctorates-s-e/2021#data).

	Fall 2016	**Fall 2017**	**Fall 2018**	**Fall 2019**	**Fall 2020**	**Fall 2021**	**Fall 2022**
Female	42.90%	41.20%	33.30%	23.80%	26.30%	36.80%	38.90%
Male	57.10%	58.80%	66.70%	76.20%	73.70%	63.20%	61.10%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Similarly, the overall proportion of Hispanics or Latinx in our program (around 11.3%) is higher than the

percentage of doctoral degrees in Mathematics and statistics awarded to members of the same group (6.1% in 2919), and to the percentage of Hispanics and Latinx among postdoctoral fellows in mathematics and statistics (2.1% in 2021).

	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
Asian				4.80%	10.50%	10.50%	5.60%
Hispanic or Latinx	14.30%	5.90%	8.30%	19.00%	15.80%	10.50%	5.60%
International	35.70%	52.90%	45.80%	47.60%	31.60%	42.10%	44.40%
White	50.00%	41.20%	45.80%	28.60%	42.10%	36.80%	44.40%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Postdocs form a particularly vulnerable professional group, due to the career uncertainty associated with these positions. Consequently, we strive to provide a welcoming and supportive environment, which is conducive to professional development and growth. In addition to university benefits that support work / life balance (family, medical, or compassionate care leave), we have implemented policies that allow postdocs to apply for an additional year of support for personal (e.g., illness or birth / adoption of a child) or professional (e.g., unusual publication delays) reasons. Such a support structure and the range of professional development activities we offer our postdocs have helped with our recruitment efforts.

I.2.c. Salaries and Travel Support

The table below describes the salary range for postdoctoral fellows in the department.
Postdocs supported by grants are typically hired on calendar (12 month) appointments, whereas departmental postdocs are on academic (9 month) appointments. This difference leads to significant discrepancies in maximum salary values. Salaries listed in the MIN column are the salaries of regular departmental postdocs; named postdocs receive a slightly higher (a few thousand dollars) compensation.

	Employee Headcount	Institutional Base Salary MIN	Institutional Base Salary MAX	Institutional Base Salary AVERAGE
2016	7	45,000	50,000	46,429
2017	14	47,476	50,500	47,692
2018	17	47,476	47,659	47,648
2019	24	47,476	65,000	50,299
2020	21	47,659	65,000	50,864
2021	19	47,659	65,000	50,557
2022	19	50,000	65,650	51,535
2023	18	50,000	55,224	51,801

The base salary of departmental postdocs increased from $45K to $50 in 7 years (2016 to 2023), which does not keep up with inflation and growing housing costs in Tucson. Such a salary base is low when compared to postdoctoral positions at other institutions and extremely low when compared to industry. Indeed, according to the 2020 Survey of Earned Doctorates (https://ncses.nsf.gov/pubs/nsf22300/report/postgraduation-trends#job-market), the median salary of "doctorate recipients with definite commitments in the United States" was, for PhDs in mathematics and computer sciences $144,000 if employed in industry, $79,000 for those employed in academe, and $61,200 for postdoctoral fellows. The 2019-20 AMS annual survey reported a first quartile of $56,000 for non-tenure-track faculty salaries in "Math Public Large Group" institutions (https://www.ams.org/profession/data/annual-survey/2019Survey-FacultySalaries-Report.pdf).

Our postdoctoral salaries are therefore in the first quartile of what comparable public institutions offer. Although the cost of living in Tucson is lower than in larger cities, it is comparable to the cost of living near many of our peer institutions. For instance, the CNN calculator (https://money.cnn.com/calculator/pf/cost-of-living/index.html) uses the cost-of-living index (https://www.coli.org/) to estimate that a $50K salary in Tucson, AZ is comparable to earning $49,854 in Chapel Hill, NC, $52,867 in Baltimore, MD, $48,445 in Minneapolis, MN, and $42,323 Champaign-Urbana, IL. Our salaries are therefore not competitive when compared to our peers.

We have considered utilizing one of our postdoctoral lines to increase salaries but decided against it, since 15 lines for a 3-year program corresponds to 5 lines per year and we consider that a cohort size of 5 is a minimum to maintain critical mass.

Each postdoc receives a start-up fund of $2,500 to cover travel or equipment expenses, as well as moving expenses. Once these have been used, they can apply to the Postdoctoral Committee for additional support. The program has a $20,000 annual budget, $15,000 of which is designated to cover travel or equipment expenses for postdocs. Funds remaining at the end of each academic year support collaborative research activities between postdocs. So far, we have been able to fund, at least partially for trips abroad, all travel requests submitted by postdocs to the postdoctoral committee. The recent budget increase (from $10,000 to $15,000 for travel and equipment expenses) has helped maintain that level of support.

I.2.d. Mentoring

The postdoc to tenured or tenure track faculty ratio is about 1/3. Each postdoc has a mentor, sometimes two. There have been a few occasions when a postdoc switched mentors as their research interests evolved. Since 2016, 40 different faculty members have served as mentors for one or more (sometimes as high as 4) postdocs. Mentors rarely advise more than one postdoc at a time.

A 3-year professional development plan for postdoctoral fellows was developed in the first year of the program, with input from faculty and postdocs. Postdocs are asked to create, with their mentors' help, a teaching and service plan for their 3 years in the program. The purpose is, in addition to developing a solid research program, to encourage participation in a broad range of service-related activities and the construction of a strong teaching portfolio, starting from lower-division calculus courses all the way to courses in the major such as analysis and algebra. We have written guidelines for mentor/mentee interactions, which emphasize the importance of setting up clear and mutually agreed-upon expectations early in the mentoring relationship. Mentors are expected to give professional guidance to their mentees (e.g., advice on responding to referee reports, feedback on grant proposals or job application documents) and to observe their classes. The mentorship may lead to, or be initiated through, research collaborations but such a level of interaction is not a requirement of the program; in particular, more independent postdocs are often ready to start developing a research program of their own and are encouraged to do so.

One of the Associate Head for Postdoctoral Programs' roles is to provide supplemental mentoring assistance to postdocs who need it. In addition, the Postdoctoral Committee conducts an annual performance review of all postdocs and provides guidance on developing and maintaining strength in all aspects of scholarship, in a way that is consistent with each postdoc's career goals. We encourage our postdocs to use their time in our department, as well as the resources we can provide, to identify which career path is right for them. We offer a range of outreach, teaching, and mentoring opportunities, which help those interested in student-centered careers build very attractive portfolios. In addition to resources available on campus, our professional development seminar includes panels or guest lectures discussing careers in industry or at national labs.

The Postdoctoral Professional Development Seminar runs every Tuesday from 10:30 am to 12:15 pm. Topics covered during the year are teaching, outreach and service opportunities in the department; teaching roundtable discussion and overview of shared teaching resources; professional development opportunities on campus; campus resources for students and how to utilize them; discussion of the annual performance review process; website development workshop; discussion on writing effective academic grants; guided roundtable discussion on how to write letters of recommendation; academic job search; overview of the academic application process; sessions to provide feedback on job statements; practice job talks given by postdocs on the job market; panels on preparing academic job statements, application and interview process, negotiating academic job offers; work-life balance; careers outside of academia; and a panel on career paths outside academia. In addition, the seminar provides a venue for postdocs to ask questions to the Associate Head and to suggest new resources or activities. It also provides a time when postdocs can talk to one another in a semi-private and welcoming environment. The seminar is run in hybrid format, with lunch served to those attending in person.

I.2.e. Exit Interviews

The director / associate head in charge of the program has conducted entry and exit interviews since its inception. We have used feedback from exit interviews to reinforce elements of the program that worked well, to add new components, and to restructure those that led to undue stress or did not accomplish their purpose. For instance, the postdocs have a Box folder where they share teaching resources; over the years, teaching materials (sample exams, worksheets, lecture notes, videos, etc.) for almost all our undergraduate courses have been collected. To facilitate the continued development and curation of this resource, which postdocs find extremely useful, we created the Teaching Representative governance position. Modifications made to the program based on suggestions from departing postdocs include adding a session on balancing professional demands to the professional development seminar and scheduling longer entry interviews. On the other hand, an annual survey that gave postdocs the opportunity to provide feedback on their mentors was discontinued after one year because most postdocs indicated they did not feel comfortable enough to give candid responses.

Feedback from exit interviews is generally quite positive, with many postdocs reporting they felt very well supported during their time in our department. They are grateful for the resources we provide (professional development seminar, postdoc website, travel funds, opportunity to engage in outreach and to teach a broad range of courses) and are satisfied with the outcome of their job search. We note however that a few (3) postdocs who did not find a job during their last year in the program declined to provide exit interviews.

I.2.f. Scholarly Activity

Postdocs are actively involved in research, teaching, and service. The latter category includes outreach (e.g., Math Circles or research presentations to high school or undergraduate students), running departmental programs such as our Undergraduate Teaching Assistantship program, seminar organization and participation in some departmental committees, as well as service to the profession (e.g., as a reviewer or a Mini symposium organizer for a national conference). In addition to teaching courses for our majors, many postdocs have proposed and taught undergraduate special topics courses. As a group, our postdocs have very strong research productivity and active participation in conferences. The curriculum vitae of current postdocs are provided with this report.

I.2.g. Trends in the Number of Postdoctoral Lines and Time Spent in the Program

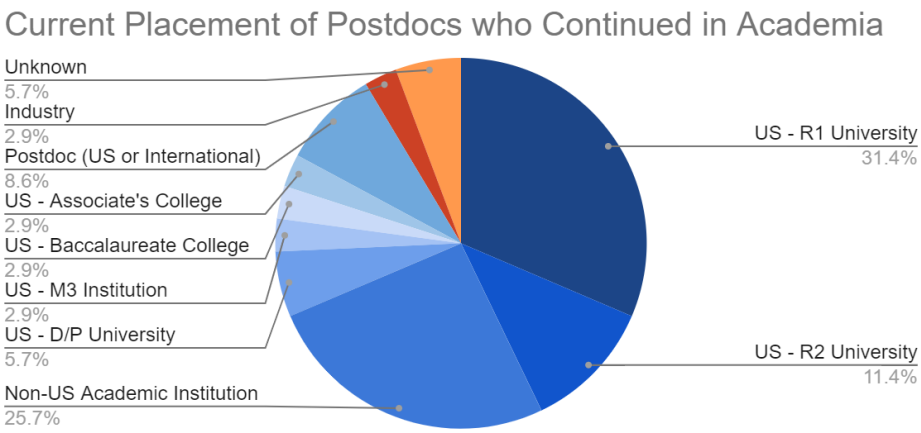
Since the program's inception, 51 postdoctoral fellows have spent an average of 2.6 years in the program, with a minimum of half a year and a maximum of 4 years. The table below shows the number of incoming and departing postdocs for each academic year since Fall 2016.

Academic Year	Number of postdocs initially in the program	New postdocs hired	Number of postdocs leaving the program	Total for academic year
2016-17	9	10	7	19
2017-18	12	9	3	21
2018-19	18	9	13	27
2019-20	14	8	9	22
2020-21	13	5	8	18
2021-22	10	7	7	17
2022-23	10	6	4	16
2023-24	12	5		17

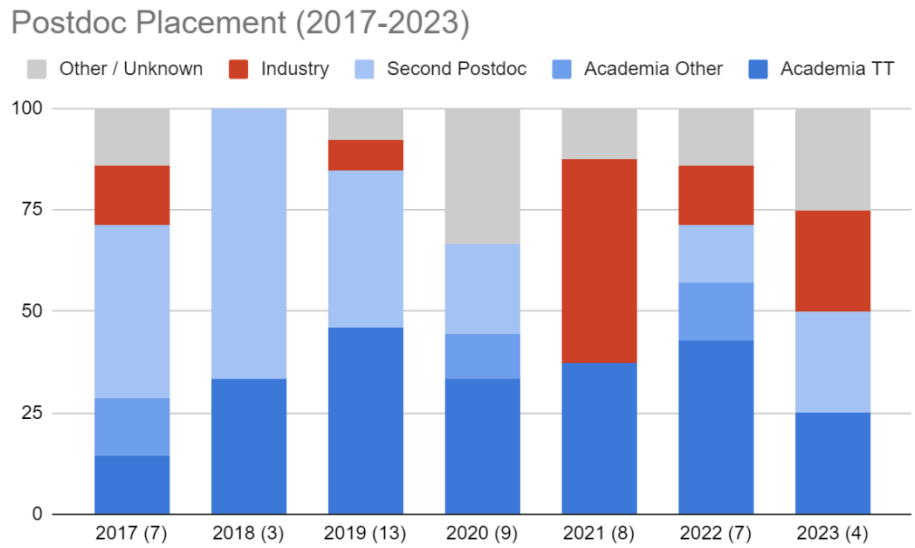
In Spring 2016, the department had 3 teaching and 2 named postdoc positions, as well as 1 NSF postdoc, 1 Math Alliance postdoc, and 2 visiting assistant professors. By supplementing permanent funding provided by the College of Science with summer revenue, we were able to hire 9 new postdocs and 1 visiting assistant professor for Fall 2016. For the next three years, we continued to hire 8 or 9 new postdocs or VAPs per year. The number of new postdoctoral hires was reduced in 2020 due to budget cuts. Since then, we have been able to supplement the 15 departmental lines with a few positions supported on grants (TRIPODS, RTG). This helped us maintain an entering cohort of at least 5 new postdocs, which is the minimum size to establish an esprit de corps within the group. Until 2019, a few visiting assistant professors were included in the program. Recently, these positions have been reserved for more advanced researchers who do not need mentoring.

I.2.h. Postdoctoral Placement

Based on exit interviews, most of our post-docs (68%) continue in academia: since 2016, 35% of the departing postdocs took a tenure track position at a public or private university (in the US or abroad) immediately after finishing our program, 6% were hired on a non-tenure track position, and 27% on another postdoctoral position. Of the remaining 32%, half took a job in industry, and half had uncertain plans at the time they left the program. In addition, those who continue in academia tend to stay in academia: of the 68% who chose an academic career upon finishing our program, 83% currently hold a permanent position in academia (in particular, 31% are at an R1 institution, 11% at an R2 university, and 26% at a non-US academic institution). Details are provided in the chart below.



The following chart shows postdoctoral placement per year of departure from the program. The increase in industry positions taken by postdoctoral fellows in 2021 is likely a reflection of the dearth of academic positions available that year as well as of the significant salary differential between academia and industry (1:2 ratio for a postdoc vs an industry position). Names of institutions or companies that hired our postdoctoral fellows are listed by category below the chart.



Academia TT: Auburn University, BIMSA (China), California State University Fresno, Missouri State University, Mount Holyoke College, Northern Arizona University, Pepperdine University, Sam Houston State University, St. Louis University, University of Florida, University of Houston, University of Minnesota, University of Oklahoma, University of South Alabama, University of Texas Arlington, Worcester Polytechnic Institute, Xiamen University (Malaysia), Zhejiang University (China)

Academia Other: Instructor (Central New Mexico Community College), Professor of Practice (University of Arizona), Assistant Professor in Residence (University of Connecticut)

Second Postdoc: Colorado State University, Duke University, Heinrich Heine University (Germany), KTH Royal Institute of Technology (Sweden), Max Planck Institute for Mathematics (Germany), Munich Center for Quantum Science and Technology, New York University Abu Dhabi, University of California Merced, University of Canterbury in Christchurch (New Zealand), University of Florida, University of

Massachusetts Amherst, University of Southern California, POSTECH (Rep. Of Korea), University of Missouri

Industry: Apple, Caris Life Sciences, Conversant, Raytheon Technologies (2), Startup Flagship Labs 74, Upstart, Wells Fargo

Other: National Science Foundation (AAAS Fellowship), PhD Program in Biostatistics at the University of Colorado Denver, Master of Finance program at the University of Arizona

J. ACADEMIC OUTREACH

J.1. Overview

The Mathematics Department has a comprehensive outreach program that engages several people in the department in a variety of activities targeting K-12 teachers, students, and families, as well as the community at large. In response to the recommendations from the last APR report, we now have a coordinator of outreach that serves as the main contact in the department for those interested in developing or participating in outreach efforts. We have also streamlined the K-12 outreach activities to address some of the challenges mentioned in the previous APR report. In this section we describe the main outreach efforts. Most of our K-12 outreach activities are under the umbrella of the Center for Recruitment and Retention of Mathematics Teachers (CRR). Most of the CRR programs have an evaluation component to address their effectiveness. This also addresses one of the recommendations from the previous APR report. We also have the Tucson Math Circle that brings in elementary and secondary school students to work on rich mathematical problems. Finally, we have the Graduate Outreach Scholar Program, through which graduate students in mathematics, applied mathematics, or statistics spend one semester doing outreach in K-12 settings as their assistantship. The last section of this report focuses on outreach efforts beyond the K-12 arena. These are activities geared to the general public.

As part of our mathematics education grants, we have outreach components that include workshops for teachers, parents, and children. Every year, the department also hosts a booth at the Tucson Festival of Books / Science City with mathematics activities for all ages. The AWM graduate student chapter organizes outreach activities for a Sonia Kovalevsky day.

J.2. K-12 Outreach Programs

J.2.a. The Center for Recruitment and Retention of Math Teachers (CRR)

The CRR (https://crr.math.arizona.edu/) an outreach center in the UArizona Department of Mathematics, was created in 2001 to address the shortage of qualified mathematics teachers at the middle and high school levels. It has since expanded to offer high-quality professional development to all Arizona PreK-14 teachers, including classroom teachers, special educators, interventionists, and long-term substitute teachers.

The Center programs serve to advance CRR's vision of an excellent mathematics teacher for every child. The CRR's Mission is to attract, develop, and support new mathematics teachers, and engage current mathematics teachers in re-imagining mathematics learning through innovative programs, retaining high-quality teachers in mathematics education.

The Center offers a wide range of services to address the needs of students, teachers, schools, and the broader community, including:

- The **New Teacher Induction Program** supports middle and high school teachers new to teaching secondary mathematics. Participating teachers coming from all areas of licensure, including alternative and international licensure, attend monthly Saturday sessions focused on

mathematics education aligned to the AZ College and Career Ready Standards, classroom management, instructional practices, effective questioning techniques, student engagement, and more. Each participating teacher is assigned a coach by the CRR who will support them in creating an effective teaching and learning environment.
    - The CRR collects retention data on new teachers on an ongoing basis. The retention data across 5 years has never been less than 85% and has most often been over 90%. In an August 2023 survey of teachers that participated in New Teacher Induction within the last 5 years, 92% of teachers responding to the survey were still in an education/teaching position.
    - 97 participants have completed the program in the last 5 years, each completing 20 hours or more of youth mentoring each year of their program participation.
- **Teacher Workshops** are offered throughout the school year to advance teachers' professional learning trajectories. Workshops are typically 2-4 hours of professional development, targeting foundational mathematics topics across the grade bands. For example, early elementary workshops may focus on counting and cardinality, while upper elementary workshops may focus on multiplication, division, and fraction sense. Middle school workshops focus on the Critical Foundation of Algebra, including ratios, proportions, expressions, equations, and functions. High school workshops cover more advanced mathematics, including proofs, non-linear change, and quantitative literacy.
    - 290 teachers have participated in 57 CRR teacher workshops from 14 Arizona counties.
- The **IMPACTS Program** is a comprehensive program that provides support for teachers and teacher leaders at all stages of their profession. The workshops support teachers' immediate efficacy with classroom instruction and student learning. The intensive Summer Institute supports teams of teachers as they dig deep into mathematics content and pedagogy, and then collaborate to advance a powerful vision of mathematics instruction at their school sites. The Teacher Leader component supports rising teacher leaders as they lead from the classroom and as they take on district level leadership roles in mathematics. The Teacher Leadership component scales up to support current teacher leaders' advocacy and leadership at state, regional, and national levels.
    - 292 teachers from 11 Arizona counties participated in the IMPACTS Program in 2021-2022. As a result, 16,475 students received high quality instruction and 90% of participating Teacher Leaders and Teacher Teams were retained in the profession.
    - In 2021-2022, the difference in state assessment scores (AASA) was statistically significant ($p=0.00931$) for students of teachers that participated as Teacher Team members, Teacher Leaders, or who participated in 3 or more IMPACTS workshops.
- The **Americorps STEMM Program** provides free mentoring and tutoring for any Arizona K-12 student. The program supports high school seniors and community college students as they prepare to matriculate to the University by providing them experience and training in serving as a mathematics K-12 mentor and tutor. The program recruits undergraduate students from all areas of the University to gain training and experience in mentoring and tutoring students in K-12 mathematics. The program partners with the MATH CATS, a student outreach group in the

Department. The program includes specific positions for university students completing their student teaching practicum, providing them financial support during their unpaid internships. These students come from programs in the Department of Mathematics as well as the College of Education and include alternative pathway student teachers in graduate programs as well. Finally, the program engages recent graduates of the university in a year-long position as a Community Based Intern at local schools situated in under-resourced communities. The STEMM program garners stellar results both for K-12 students receiving services, programs serving vulnerable populations in schools, and the program members.

    - 22 AmeriCorps members chose to continue their work in education after their term of service. 31% of AmeriCorps members chose to serve another term. 2,417 students were served from 9 counties in Arizona. 704 students received high intensity service (3 hours per week for at least 18 weeks). 100% of the high intensity students' disposition towards school and mathematics improved, this is in comparison to 28% of students in their schools that did not participate.

- The **Mathematics Educator's Appreciation Day Conference** (MEAD) hosts over 1000 Arizona teachers each year for a half-day of intensive professional development sessions, followed by a luncheon and keynote address by a nationally recognized leader in mathematics education. Unique to this conference, speakers are local teachers and leaders, sharing promising practices that can be implemented immediately by other teachers. As the largest mathematics education event in the state, MEAD is regularly attended by university and public officials, including College of Science administrators, university representatives, Superintendents of Education, and the Mayor of Tucson. Furthermore, state, and national officials, such as Governor Hobbs and Senator Kelly, demonstrate their support for teachers by recording video remarks to be shared with attending teachers.
    - In January 2023, 1,000 teachers from 14 Arizona counties attended more than 120 sessions and a keynote address from Margaret "Peg" Smith, recipient of the Lifetime Achievement Award from the National Council of Teachers of Mathematics.
- **Advanced Placements (AP) Practice Exam Day** allows high school students from across Arizona to experience an entire practice AP exam in Calculus AB, Calculus BC, or Statistics. After completing the exam, students participate in a workshop with AP exam designers and scorers in order to understand how the exam is scored, and to determine their current score. Concurrently, AP teachers engage in professional development around innovations in AP courses, instruction, and exams.
    - In 2023, 205 students and 19 teachers participated in the AP Practice Exam Day from 5 Arizona counties. Students that participated in AP Calculus AB and Statistics practice exams had a statistically significant difference on the actual AP exam than their counterparts ($p<0.001$). For Calculus BC, there was still a statistically significant difference ($p=0.015$).
- **Community Events** provide an opportunity for the CRR to engage directly with youth, families, and community members. The CRR hosts Community Game Nights for families across Arizona. Additionally, the CRR supports activities and engages with communities through Math Nights,

STEM Fairs, parent workshops, and Pi Day, including fun and exciting activities that help people enjoy, appreciate, and connect with mathematics and each other.

  - More than 100 attendees from four Arizona counties participated in Community Game Night 2023.
  - The AmeriCorps STEMM members participated alongside 491 volunteers at 9 STEM events across their communities.

- The CRR provides schools with program materials and training to re-engage learners in exciting mathematics experiences while meeting their needs and intentionally developing connections to fully engage Aspirational Learners in their school community. As a result of disrupted learning caused by the pandemic, the CRR recognized the need to support schools with a program that could improve community and connection among students and school staff, as well as support students' re-engagement in school and in mathematics. The **Re-Engaging Aspirational Learners program** (Getting REAL) was developed to support students' mathematics success in light of unfinished learning, while also helping them re-engage in their school community.
  - More than 250 teachers from eight Arizona counties participated in training and/or received support from the Getting REAL program.
  - The Getting REAL program was able to improve the mathematics and school disposition of 1325 students in Arizona, and the mathematical proficiency for these Arizona students. 1,418 students submitted work that showed improved proficiency and improved mathematical behaviors. Each piece of work showed improvement in at least two key areas, a significant improvement, and a great start to recovering from unfinished learning.
- The CRR engages **University partners** to coordinate outreach efforts and leverage the Center's reach and reputation across the state. For example, the CRR collaborates with university teacher preparation programs, as well as University induction and teacher support efforts. Within the Department of Mathematics, the CRR supports the Math Cats and Math Circles (described later in this report), while also providing mentorship opportunities for graduate students, including Outreach Scholars (described later in this report). Furthermore, the CRR collaborates with research efforts across multiple University and Colleges.

The above services represent some, but not all, of CRR's efforts to promote excellent mathematics instruction for ALL Arizona students. To aid in this work, the CRR is committed to offering all of its professional development in a hybrid format, allowing for both in-person and online participants. This allows for expanded access beyond the Tucson area, reaching every corner of the state. Though this commitment was founded before the Covid pandemic, it was the CRR's rapid pivot to support online learning during school closures that accelerated statewide expansion, resulting in recognition from and partnership with the Arizona Department of Education (ADE). State leadership recognized the value of the CRR's workshops for teachers (100 virtual workshops in the first 60 days of the lockdown), math menus and tutoring for families, and intervention curriculum for schools to address disrupted learning, and promoted the CRR as the go-to organization for the state's mathematics education needs. To exemplify, then Arizona Superintendent of Public Instruction, Kathy Hoffman, formally acknowledged the

CRR in both her State of Education and State of Special Education remarks to the Arizona legislature, including:

"Now more than ever our state needs highly qualified teachers who can teach core subjects like mathematics. The Center's work dedicated to this endeavor has helped accelerate students' achievements and will be a great asset as the state continues to recover from lingering impacts of the pandemic."

As evidenced by the range of services and the data referenced from Center evaluation and reporting, the CRR continually adapts to the needs of the mathematics community and assesses the impact of Center initiatives. With a 20+ year record of offering exceptional support to Arizona's teachers and schools, the Center is well-regarded in all corners of the educational landscape, resulting in an ever-expanding list of collaborators and partners both within and beyond the University, including foundations and non-profit organizations.

J.2.b. The Tucson Math Circle

The University of Arizona (Tucson) Math Circle (TMC) is a community combining local K-12 students with UArizona faculty, postdocs, graduate, and undergraduate students. Its mission is to inspire interest in mathematics (and sciences in general) by providing a friendly and stress-free environment where participants explore exciting areas of mathematics commonly left outside of the regular school curriculum. TMC also conducts MAA AMC8/10/12 mathematics competitions.

Over the course of the last fifteen years the TMC has been organized by I. Fatkullin and has been functioning thanks to the enthusiastic effort of volunteer instructors from the UArizona Mathematics Department. Professors, such as B. Bailey, S. Cherkis, and A. Izosimov contributed lectures and/or study materials; postdoctoral fellows, such as C. Duron, N. Fider, Y. S. Moon, J. Peca-Medlin, A. Zerouali, and J. Xue led sessions both in-person and on- line (which started during the pandemic period). Currently, the in-person sessions are run by the dedicated team of our graduate students, A. Borwankar, B. Kale, M. Lamb, H. Morseth, and K. Van. Many others had participated in the previous years, e.g., E. Forletta, R. Knack, G. Korpal, A. Loomis, T. Phillips, M. Stone, and G. Zhelezov prior to 2020.

The meetings combine lectures on various topics, such as number theory, combinatorics, graphs, game theory, theory of probability, etc., and also problem-solving sessions. The TMC provides the UArizona graduate students and postdocs an invaluable opportunity to learn how to teach and communicate complex and abstract mathematical concepts using simple language and engages the K-12 students in mathematics and science. Simultaneously, these senior math circle members serve as mathematician role models to its younger participants and attach social capital to the learning and practice of mathematics. The parents often enjoy this activity too: a few families attend TMC sessions driving all the way from Phoenix (which is over 100 miles away). The TMC members have also participated in events taking place at the University of Arizona Flandrau Science Center and Planetarium, e.g., the Annual Chess and Science Festival. Many of the students attending the math circle have placed highly in MAA American Mathematics Competitions (conducted in UArizona facilities), Mathcounts, and Mathematics

Olympiad and further on continued their education in STEM-related fields (frequently returning to the University of Arizona as college students).

During the years of the pandemic the TMC started an online program: currently it holds weekly zoom sessions for junior (under the age of twelve) students under the leadership of J. Peca-Medlin and C. Duron (now an Assistant Professor at Pepperdine). The in-person program for senior (over the age of twelve) students has just restarted this year (2023) and has been seeing an increasing number of students from a variety of local schools, such as Mountain View, Sunnyside, Empire, and Basis. Another recent initiative led by TMC's graduate students is to create a website as a free global resource that would support the formation and functioning of math circles everywhere in the world. The website will contain all worksheets from TMC's sessions organized by date and topic, with notes, supplemental materials, and teaching methods.

In terms of number of participants in the pre-pandemic year, TMC had about 30 regular participants every season, with from 8 to 12 present in each session. During the pandemic there were about 20 students across the two divisions (junior/session) who attended some Zoom sessions, with each session usually having from 5 to 7 students (in each division). This seems to be the same for the current junior online session as well as for the current in-person sessions (Fall 2023).

J.2.c. The Graduate Outreach Scholar Program

The Graduate Outreach Scholar Program is a way to formalize and support various forms of community service done by graduate students in the mathematical sciences. The students are experts in mathematics, and the activities are meant to utilize this resource for the benefit of the community though activities with K-12 students, parents, K-12 teachers, and the broader community. Quite often Graduate Outreach Scholars develop and implement activities that help communicate some aspects of mathematics that K-12 students may not formally see in their schooling but that can help them understand the beauty and applications of this area of study. From 2016 till 2019 we had 11 outreach scholars. The program was put on hold during the pandemic and is set to start again with one graduate outreach scholar in Spring 2024 and one in Fall 2024. Up to now the graduate outreach scholars were mostly placed in local schools to work alongside one or two teachers, under the supervision and mentoring of the Outreach Coordinator). The scholars provided in-class support as well as helped organize after-school activities and math family events. Starting in Spring 2024 the program will be housed within the CRR under the guidance of its co-directors Melissa Hosten and Rodrigo Gutiérrez. CRR has multiple projects which will make it easy for the Scholars to contribute to several K-12 initiatives (e.g., Math Family Events, CRR workshops, MEAD conference, working with local teachers). The Outreach Coordinator will continue to be their supervisor and mentor.

The Graduate Outreach Scholar Program provides a unique opportunity for graduate students to not only engage in outreach but to also learn more about the teaching and learning of mathematics and about themselves as teachers. Outreach scholars who have participated in these experiences have shared that it has helped them strengthen their own teaching at the University. By seeing the kinds of

challenges that some students face when learning mathematics in K-12, it has allowed them to make connections to the challenges that students in college classes often face. Below are some reflections from past Outreach Scholars:

> By explaining these topics at a more basic level, it will help graduate TAs improve their ability to teach those topics at the college level. The second main benefit, which I consider the most important, is that the students that take the lower-level (before calculus) math classes at the U of A are mostly students who struggled with ("hated") math in middle and high school. By working with these struggling eighth graders individually, I am seeing the very beginning of these math struggles. I am getting to understand the foundation of lifelong difficulties with math, as well as learning techniques to connect with struggling students and help them overcome these difficulties, and I think that this will help me better reach my struggling college students. [Spring 2017]
>
> The outreach experience can give graduate students a better understanding of what are the needs in the community and what they can do to improve the current circumstances. This might lead to community involvement, future research projects, and networking which are valuable additions to the graduate student curriculum. In the future, these additions will set the graduate student apart from the rest of the applicants when applying for jobs in either academia or industry. [Spring 2017]
>
> Now that I can reflect on this experience in its totality, I am really overcome by emotions... Through this experience I really came to discover my desire for interacting with, educating, and motivating students with whom I share such a similar background. I have not felt this way through other teaching roles, such as being a TA in the department, or when I was a tutor for more affluent children as an undergraduate. It is difficult to articulate just how deeply and profoundly this experience has impacted me. I even feel like this experience has let me recover a piece of my cultural identity that was whitewashed over my now 7+ years as a college student. I do not exaggerate when I say I think this experience has allowed me to rediscover myself. Thank you for the opportunity to be an outreach scholar. This was overall the best teaching role I have had as a graduate student and has been a truly life changing experience. [Fall 2019]

J.3. Public-Facing Mathematics Outreach

A portion of the Department's outreach efforts are oriented towards the general public. This public-facing outreach seeks to engage external stakeholders' curiosity in the mathematical sciences, as well as learn from and collaborate with the local community to advance causes or issues where mathematics plays a useful role. Public-facing outreach efforts include regular events and publications (two endowed lecture series, an annual newsletter) as well as other ad-hoc or one-time events. Over the current APR period the department has:

1. **Hosted** the 9th, 10th, and 11th Daniel Bartlett Memorial Lectures (2017-19), each given by a renowned mathematician skilled in engaging general audiences in aspects of their research. The

Bartlett lecture, established in 2008 and supported in part by a generous endowment, generally attracts upwards of 300 attendees and may be streamed online.

2. **Established and hosted** the first six Buell Everything is Mathematics (EIM) public lectures (2017-19), each given by one of our own faculty members, specially coached to successfully engage in sharing their research with the public. EIM, established in 2017 through an endowment, is hosted in public venues in downtown Tucson and may be streamed online.
3. **Produced and published** issues XVII-XXIII of the Mathematics Newsletter (2017-23), a public-facing publication featuring mathematics research, teaching, and engagement authored by our own faculty, instructors, students, alumni, and board members. Print newsletters are mailed to nearly 1000 donors and friends of the School of Mathematical sciences annually; the publication is browsable online.
4. **Organized and hosted** a two-day Conference on Redistricting (2018), a multidisciplinary public forum free and open to the public, where national experts and community leaders addressed math, law, and politics in redistricting as well as Arizona as a model for redistricting reform. The conference, which brought together 19 speakers and panelists from across the nation, was a collaboration across local organizations and other UArizona units, including the James E. Rogers College of Law and the School of Government and Public Policy.
5. **Organized and hosted** a first-ever virtual event for students and the public featuring the role of mathematics in corporate careers. Curated Conversations: Cancer, Equity and the Mathematical Sciences (2021) served to connect students, corporate leadership, and community members to learn about careers in what is now part of one of the largest global biotech companies. The conversation may be streamed online.

Both endowed lecture series remained in-person public events and were thus paused over the pandemic. They are scheduled to resume in 2024.

J.4. Conclusion

As a central department in a land-grant university and flagship campus of the state system, we believe that our responsibilities include enhancing public awareness of and appreciation for the mathematical sciences, providing exceptional opportunities for mathematically oriented young people, and developing a robust and well-trained corps of mathematics educators to staff secondary schools. The activities described in this section address these needs, and some of them (such as CRR and the Graduate Outreach Scholar program) are unique and could serve as models for other institutions.

K. COLLABORATION WITH OTHER UNITS

The Department has deep and extensive collaborations with many other units on campus, most notably with the Graduate Interdisciplinary Programs (GIDPs) in Applied Mathematics and in Statistics and Data Science.

Thirty faculty members in Mathematics are members of the Program in Applied Mathematics (out of 123 total), four serve on the steering committee (of nine total), and the current and all past chairs of the program have had their primary faculty appointments in Mathematics. The department teaches the core courses for the PhD in Applied Math (MATH 581A/B, Math 584A/B, and MATH 589A/B), it administers their qualifying exams, and during the review period departmental faculty supervised just over half of the dissertations completed in the program. The department currently provides space for 58 students from the program and employs many of them as GTAs, training and mentoring them as teaching assistants and in some cases as instructors of record. The program's offices are in our building. The department and the GIDP are developing a new professional master's degree in applied mathematics which for financial reasons will be housed in the department.

Relations with Statistics and Data Science are similar: 11 faculty members in Mathematics are members of the Program (out of 45 total), three serve on the steering committee (of six total), and the current and all past chairs of the program have had their primary faculty appointments in Mathematics. The department teaches the core courses for the PhD in Statistics (MATH 564, MATH 566, MATH 571A/B, Math 574M, and STAT 688A/B), it administers their qualifying exams, and during the review period departmental faculty supervised about half of the dissertations completed in the program. The department currently provides space for 54 students from the program and employs many of them as GTAs, training and mentoring them as teaching assistants and in some cases as instructors of record. The program's offices are in our building. Starting in Fall 2024, the department will offer a professional master's degree in Statistics and Data Science.

Our faculty includes members of several other GIDPs and research institutes: Cognitive Science, Genetics, Neuroscience, Bio5, Cyverse, Data7. The director of the Data Academy, Joe Watkins, has his primary appointment in Mathematics. Guadalupe Lozano, the director of the Center for University Education Scholarship, has her primary appointment in Mathematics.

Our faculty hold joint (courtesy) appointments in the following departments: Agricultural-Biosystems Engineering, Biomedical Engineering, Physics, Public Health, and Teaching/Learning and Sociocultural Studies. One faculty member has a shared appointment (50/50) with Optical Science.

The department collaborates with Arizona International to offer a dual degree program with the Capital University of Economics and Business in Beijing. Students in this four-year program take basic courses from Chinese faculty and advanced courses from Arizona faculty (all in-person in Beijing) leading to a degree from CUEB and the BS in Statistics and Data Science from Arizona.

The department collaborates with Arizona Online to offer a wide range of support courses for online degrees in Bioinformatics, Biology, Ecology and Evolutionary Biology, Electrical and Computer Engineering, Neuroscience and Cognitive Science, Psychology, and Software Engineering.

The department is working with several other units in the College of Science to develop emphasis tracks in the BA/BS in Statistics and Data Science. Tracks in Applied Statistics, Comprehensive Statistics, Computer Science, and Molecular and Cellular Biology are currently in the approval process, and tracks in Astronomy, Geosciences, Hydrology and Atmospheric Sciences, and Neuroscience and Cognitive Science are planned for the near future.
Our Associate Head for STEM instruction consults regularly with faculty members from Science Departments, the College of Engineering, College of Education, and the Eller College of Management to align our curriculum with the needs of their majors.

L. FACULTY PLANNING

The department's policies, curriculum, and programs are set by 20 standing committees (described in Section F) whose membership is determined partly by election and partly by appointment. In many cases, these committees include representation of tenure track and continuing status faculty as well as career track faculty (instructors and lecturers). Graduate students and postdocs are also represented when appropriate. We seek a good balance between involving faculty in major decisions while not burdening them with administrivia so that they can focus on their core contributions in research and teaching.

The department has a culture of continuous experimentation and improvement. During this academic year, several long-term planning exercises were undertaken either as part of or in parallel with this self-study. The department's planning committee made a thorough revision of our bylaws with the aim of increasing inclusivity, eliminating obsolete committees, and introducing new ones (e.g., for Climate and DEI), and fixing technical issues. The department's personnel committee developed two documents, one on the mechanics of the hiring process (a specific request from the junior faculty) and another on priority areas of research. An ad hoc "resources task force" produced a simplified account of the department's financial position (income and expenses, assets, and liabilities). Their report will be especially useful as we navigate the financial storms created by the central administration in 2023.

Here are links to the reports mentioned above:

Report on Bylaws by the Planning Committee
https://www.math.arizona.edu/files/APR2024/BylawsRevision.pdf

Hiring plan documents
https://www.math.arizona.edu/files/APR2024/HiringPlan.pdf

M. SPECIAL CONSIDERATIONS: THRESHOLD FOR DEFINING PRODUCTIVE PROGRAMS

ABOR requires that programs with low degree production do an evaluation and report the results to the Board as part of the APR. The table in Appendix C of the APR Manual shows the minimum number of degrees a program is required to produce. Units with programs that have failed to attain the required number of degrees over three years will be notified by the Office of Curricular Affairs. Methodology for this report is found in Appendix C. Discuss this issue in the self-study report. Contact the APR self-study editor if you have questions.

The Department of Mathematics does not have programs with low degree production.

APPENDICES

Links to the associated files are provided below.

A. FACULTY CVS

https://www.math.arizona.edu/files/APR2024/CVs.pdf

B. UNDERGRADUATE PROGRAM

B.1. 2023 Handbook https://www.math.arizona.edu/files/APR2024/uhandbook.pdf

B.2. ADE-SMEP Accreditation Approval Letter September 2023

https://www.math.arizona.edu/files/APR2024/SMEPAccreditation.pdf

C. GRADUATE PROGRAM

C.1. Intersectional Demographics of PhD Students by Year

https://www.math.arizona.edu/files/APR2024/Demographics.pdf

C.2. First Job Placement of PhD Graduates

https://www.math.arizona.edu/files/APR2024/FirstJobPhD.pdf

C.3. Talks by Graduate Students

https://www.math.arizona.edu/files/APR2024/Talks.pdf

C.4. Publications by Graduate Students

https://www.math.arizona.edu/files/APR2024/Publications.pdf

D. Required Institutional Data

D.1. Undergraduate https://www.math.arizona.edu/files/APR2024/UgradRequiredData.pdf

D.2. Graduate https://www.math.arizona.edu/files/APR2024/GradRequiredData.pdf

D.3. Faculty https://www.math.arizona.edu/files/APR2024/FacultyRequiredData.pdf

D.4. Staff https://www.math.arizona.edu/files/APR2024/StaffRequiredData.pdf

D.5. Space https://www.math.arizona.edu/files/APR2024/SpaceRequiredData.pdf

E. Other APR Files

C.2. Resource Task Force Report

https://www.math.arizona.edu/files/APR2024/ResourceReport.pdf

E.2. List of Faculty Awards Detail

https://www.math.arizona.edu/files/APR2024/Awards.xlsx

E.4. Student Course Survey (SCS) Data, 2019 to 2023

https://www.math.arizona.edu/files/APR2024/Studentsurvey.pdf

F.1. Organizational Chart

https://www.math.arizona.edu/files/APR2024/orgchart.pdf

H.13. Undergraduate

Undergraduate Assessment - Math Major, 2022-23

https://www.math.arizona.edu/files/APR2024/BSBAMath2022-2023.pdf

Undergraduate Assessment - SDS Major, 2022-23

https://www.math.arizona.edu/files/APR2024/BSBASDS2022-2023.pdf

Undergraduate Assessment - Math Major, pre-2022
https://www.math.arizona.edu/files/APR2024/BSBAMathpre2022.pdf
Undergraduate Assessment - SDS Major, pre-2022
https://www.math.arizona.edu/files/APR2024/BSBASDSpre2022.pdf
I.4. Graduate
Graduate Assessment-MS
https://www.math.arizona.edu/files/APR2024/MSAssessment.pdf
Graduate Assessment- PhD
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L. Updates to Bylaws
https://www.math.arizona.edu/files/APR2024/BylawsRevision.pdf
Hiring Plan
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