Board 408: The S-STEM Program for Mathematics Majors at the University of Texas at Arlington

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Dr. Aktosun is a professor of mathematics at the University of Texas at Arlington. His research area is applied mathematics and differential equations with research interests in scattering and spectral theory, inverse problems, wave propagation, and integrable evolution equations. He is involved in various mentoring and scholarship programs benefiting students. He has been the GAANN Fellowship Director in his department during 2006-2022, the NSF S-STEM Scholarship Director in his department since 2008, and he also acts as the Project Director for the NSF Bridge Program in his department. In the past he served as the Graduate Director and as the Undergraduate Director in his department, and he directed the NSF-LSAMP program on his campus during 2009-2014 and also directed the NSF-LSAMP Bridge-to-Doctorate program on his campus during 2010-2013.

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Dr. Yolanda A. Parker has been an educator for over 25 years and has been full-time faculty at Tarrant County College-South Campus for over 10 years in the Mathematics Department where she primarily teaches Statistics and Math for Teachers courses. She has a B.S. in Applied Math from Texas A&M University in College Station, TX; M.A. in Liberal Studies from Dartmouth College in Hanover, NH; and Ph.D. in Mathematics Education from Illinois State University in Normal, IL.

Prof. Jianzhong Su, The University of Texas, Arlington

Dr. Jianzhong Su is professor and chair of Mathematics at the Department of Mathematics, University of Texas at Arlington (UTA). He received his Ph.D. in 1990 from University of Minnesota under Professor Hans Weinberger and he has been in higher education for over 29 years. He is an applied mathematician with research areas in partial differential equations and dynamical systems, with a particular interest in problems from computational neuroscience. He is an experienced researcher, educator, and administrator. He has served as PI/co-PI on over $10 million federal research, education and training funding from National Science Foundation, National Institutes of Health, US Department of Education, US Department of Agriculture and other agencies, published over 70 peer-reviewed journal papers and been invited to over 70 seminars and conferences, and advised over 10 math students who attained their Ph.D. degree. He is very involved student mentoring of undergraduate students and high school students. He has been leading the development of the UTA learning communities and tutoring program for undergraduate and graduate students and has provided space and travel funds to enhance the UTA model. He is an active member of Gulf States Math Alliance and serves on its board of directors and co-organized the annual Gulf States Math Alliance conference in 2017-2020. Currently he is the PI on an NSF Math bridge to doctorate program at UTA. He also serves as a PI on a large UTA USDA-HSI collaboration project on smart agriculture data and mentoring students to research in data science and to pursue agricultural related career. His information can be found in https://www.uta.edu/academics/faculty/profile?username=su

The S-STEM program for mathematics majors at the University of Texas at Arlington

1. INTRODUCTION

With the grant support from the Division of Undergraduate Education (DUE) at the National Science Foundation (NSF), we have been running an S-STEM program [1] in the Mathematics Department at the University of Texas at Arlington (UTA) since 2008. In this paper we present the basic information about our S-STEM program and shares some lessons learned over the years to run the program better for the benefit of the participants and also for the PI team involved. The information contained here provides an update on our S-STEM program as of April 2023, and it supplements the data provided in some previous papers [2,3,4].

Our S-STEM program uses the acronym SURGE, formed from some of the initials of the full title "A Comprehensive **S**ystem for **U**ndergraduates to **R**each **G**oals in **E**ducation." An acronym easy to remember helps to easily identify our program in communications for everyone involved, and that is why we are happy with the choice of our acronym. Our PI team consists of five tenured faculty members, who are all actively teaching mathematics both at the undergraduate and graduate levels. The PI team includes the department chair as a co-PI, the graduate director as a co-PI, two faculty members who routinely teach the key upper-level undergraduate mathematics courses, and the PI with experience in running various similar scholarship and mentorship programs such as the **G**raduate **A**ssistance in **A**reas of **N**ational **N**eed (GAANN) program [5], the **L**ouis **S**tokes **A**lliance for **M**inority **P**articipation (LSAMP), and the LSAMP **B**ridge to the **D**octorate (LSAMP-BD) program. Besides the five-faculty PI Team, there are a few other key persons or campus offices involved in our S-STEM program, and they consist of the Undergraduate Mathematics Advisor, the UTA Financial Aid and Scholarship Office, the Office of UTA Analytics providing institutional data, our external evaluator who is a professor of mathematics specializing in mathematics education at a nearby institution, the Office of Grants and Contracts on our campus, the UTA Post Award Manager, the UTA Pre award Manager, and three key staff members in our department. Having the devoted and reliable and supportive key personnel, we are able to run the program efficiently and resolve any issues very quickly because it would be extremely inefficient, time consuming, and burdensome to run the program without the help from all involved. Everyone involved in our S-STEM program has

formed over the years a close and respectful partnership and feels the ownership of the program without the involvement of everyone in the entire partnership mentioned. No one in our S-STEM program feels that someone else owns and runs the program and that the rest are obligated to help the owner of the program. Everyone in the partnership shares the success of the program, and everyone involved clearly understands the program's goal of mentoring, graduating, and transitioning of our students to career paths.

Everyone involved in our S-STEM program plays a key role. Over the years, we have learned how to effectively communicate with all eligible students to encourage them to apply to our program, to efficiently recruit to our program, to check their eligibility, to collect the appropriate data from the scholars in our program, to minimize the burden on our students, to check the scholars' academic progress, to provide them with better academic advice, to encourage them to interact with each other, to take advantage of many opportunities available both on campus and elsewhere, and how to run the program better for the benefit of everyone involved.

2. THE RECRUITMENT, ADMISSION, AND MENTORING

Our university is on the semester system, and we now recruit and admit the scholars every semester. There is no automatic continuation of the scholarship from one semester to the next. About a week before the semester, an e-mail is sent to all the mathematics majors, inviting those eligible to apply via e-mail by providing brief responses to a set of questions included in the invitation e-mail. The response also contains an item where the applicant can describe any special circumstances that may exist for that applicant. The same invitation e-mail is again sent to all the mathematics majors in the first week of classes to ensure that everyone who is eligible can apply. The e-mail sent to all the mathematics majors clearly indicates the eligibility criteria and encourages the recipients to contact the PI for any clarifications. The PI in our S-STEM program receives all the e-mail responses by the applicants, acknowledges their receipts by communicating with the applicants, shares the applications via e-mail with the rest of the PI team members and the Undergraduate Advisor. The process is not burdensome for the applicants at all as only the key information is collected from the applicants. The PI has an easy online access to the students' academic records and can easily check and verify the applicants' information provided, such as their previous semester course grades, their GPAs, their semester course load, and other relevant academic information.

As the e-mail applications come in, the PI communicates via e-mail with the key financial aid officer and requests the applicants' unmet financial need data. An excel file containing the financial data provided is sent to the PI via e-mail by our key contact in the UTA Financial Aid Office. The excel file contains the cumulative data in the sense that all the students' data are updated for all the previous semesters' applicants until they graduate. The data contains all the relevant information to determine the financial eligibility, the cost of attendance, the expected family contribution, all other scholarship awarded to the student, any work study offers made to the student, and the number of credit hours the student is taking in the current semester. The PI has all the relevant information to identify the financial eligibility of all the low-income students and the exact amount of eligibility with the understanding that the S-STEM money will be the last-dollar scholarship to be distributed by the UTA Financial Aid Office to the admitted scholar.

With the input from the remaining PI team members and the Undergraduate Mathematics Advisor, the PI prepares a brief summary of status for each applicant. For most applicants, a decision to admit or not is relatively easy based on the eligibility criteria. We basically ask ourselves, with the mentoring and scholarship provided to the applicant, whether that applicant will receive a bachelor's degree in mathematics and will receive the degree in a timely manner. The decision is easier to make for the applicants who have demonstrated that they can handle one key course taken by all the mathematics majors, namely the Introduction to Proofs. However, it is very important for us to have a holistic review of each applicant. There may be some undergraduate students who have not yet taken the Introduction to Proofs, and in such cases we need to make an assessment whether the applicant will be able to receive a bachelor's degree or will quit the mathematical studies before receiving a bachelor's degree. This is the reason why the PI interviews each applicant, one person at a time. The interviews allow us to make the appropriate admission decision for each applicant. The interviews show the determination, devotion, and resilience of each applicant, and the PI is able to decide whether to admit the applicant now or ask the applicant to apply again next semester after we see the applicant's academic performance in the current semester.

The PI and the key financial aid officer work very closely throughout the semester. In fact, for all those applicants under consideration for the S-STEM scholarship, the financial aid officer ensures that those students, while under consideration, would not be dropped from any courses for which they have signed up for the current semester, as it is the UTA policy to remove the

students from a course if the tuition and fees are not paid by a certain deadline. In any case, the PI completes the interviews and the admission process very quickly and informs all the applicants via e-mail of their application status. Those who are admitted are asked to sign their offer letter and e-mail it to the key Mathematics Department Administrator who quickly communicates with the appropriate parties in the UTA Grant Office and the UTA Financial Aid Office so that the award funds are processed quickly through the Financial Aid Office. While sending the scholarship offers to the admitted applicants via e-mail, in addition to the attached offer letter there is also an attached file containing a brief set of questions. Those admitted answer those questions on the file and e-mail the file back to the PI. The PI uses the information contained in that file to provide the relevant information for the scholar at the s-stem.org webpage. This process minimizes the burden on both the PI and the applicants. Normally, the only other time any information is collected from the scholars is on the last week of classes where the scholars respond to the online survey prepared by our external evaluator. Even though the scholars are not mandated to respond to that survey, they all understand the importance of the external evaluator's report in our S-STEM program and hence they all respond in a timely manner. The survey also allows the scholars to provide input for any improvements in our S-STEM program, and the scholars feel comfortable to provide input. The survey is not burdensome on the responding scholars, especially because it is conducted online.

Once the scholars are selected for our S-STEM program, the PI sends an e-mail to all the participants as well as the key persons involved in running the program. The e-mail contains all the relevant information about the program for that semester, including all the names and e-mail addresses, so that everyone can communicate each other easily and the participants can contact the key persons at any time on any issue. We have monthly meetings for our S-STEM program, on the first Monday of every month in the semester. Those meetings take place during 12:00 noon-12:50 pm, a period when no classes are scheduled so that the students can participate in various activities. The meeting dates and the meeting room are arranged ahead of time so that we do not worry about the logistics for each meeting. The meeting room is already familiar with all the mathematics majors, and it is usually one of the mathematics classrooms on the third floor of the building in which our department is located. Hence, even if a participant has class before or after our S-STEM meeting, this does not present any problem. We also finish our meetings on time so that none of the participants are late for their next classes. During those monthly

meetings, the catered lunch is served by taking into consideration everyone's dietary restrictions. These meetings provide an excellent opportunity for everyone to interact with each other, form collaborations, exchange ideas, get suggestions for academic success, learn about professional organizations, learn about internships and career opportunities, learn about supervised research opportunities.

3. DATA FOR THE UTA MATHEMATICS PROGRAMS

The undergraduate and graduate programs in our department have direct relevance on our S-STEM program in mathematics. This is because we recruit our S-STEM scholars only among the undergraduate students majoring in mathematics, and that about half of our S-STEM scholars move to graduate studies after they receive their bachelor's degrees in mathematics.

Next, we present the updated enrollment data in the mathematics programs at UTA since the fall semester of 2005. In the plots presented, the horizontal axis shows 36 data points, where the point 1 corresponds to Fall 2005, the point 2 corresponds to Spring 2006, the point 3 to Fall 2006, etc. In particular, the point 5 corresponds to Fall 2007, the point 10 to Spring 2010, the point 15 to Fall 2012, the point 20 to Spring 2015, the point 25 to Fall 2017, the point 30 to Spring 2020, the point 35 to Fall 2022, and the point 36 to Spring 2023. The change starting from Spring 2020 can be, at least partially, interpreted as the change during the Covid-19 pandemic.

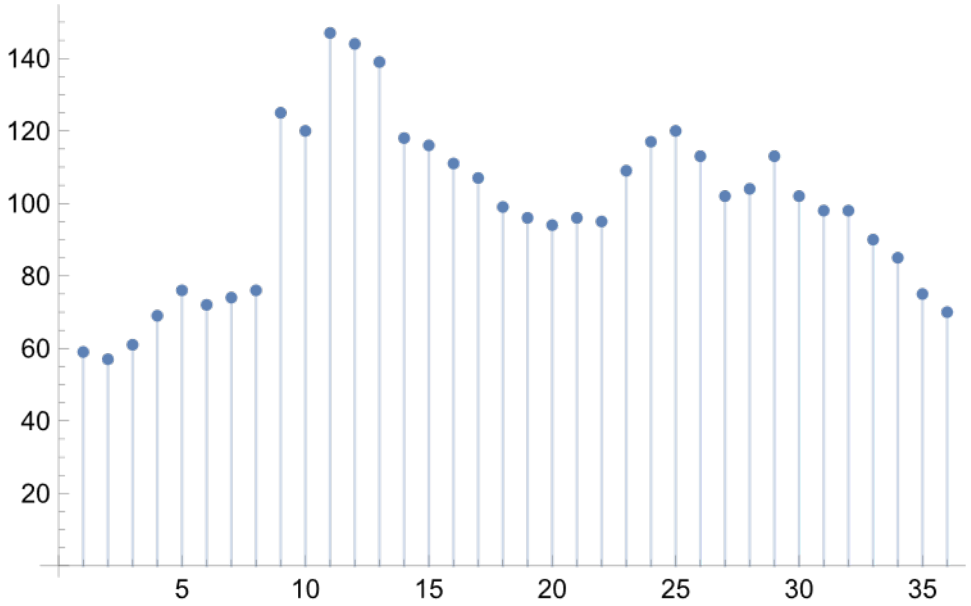

Figure 1. The UTA math graduate student enrollment from Fall 2005 to Spring 2023

Figure 1 shows the number of graduate students in the UTA Mathematics Department since the fall of 2005. The fall 2005 enrollment number was 59 and the spring 2023 enrollment number was 70. During the Covid-19 pandemic, the number of mathematics graduate students decreased from 102 in Spring 2020 to 70 in Spring 2023. This decrease is mainly due to the fact the number of incoming graduate students has decreased. In fact, the number of PhD degrees awarded in our department remained relatively high; namely, 13 in year 2020, 11 in year 2021, and 12 in year 2022. Among the 70 mathematics graduate students in Spring 2023, there were 4 (6%) master's students and 66 (94%) doctoral students. As in many PhD granting mathematics departments in the United States, in the UTA Mathematics Department the funding for graduate students is mostly for PhD students and not for master's students.

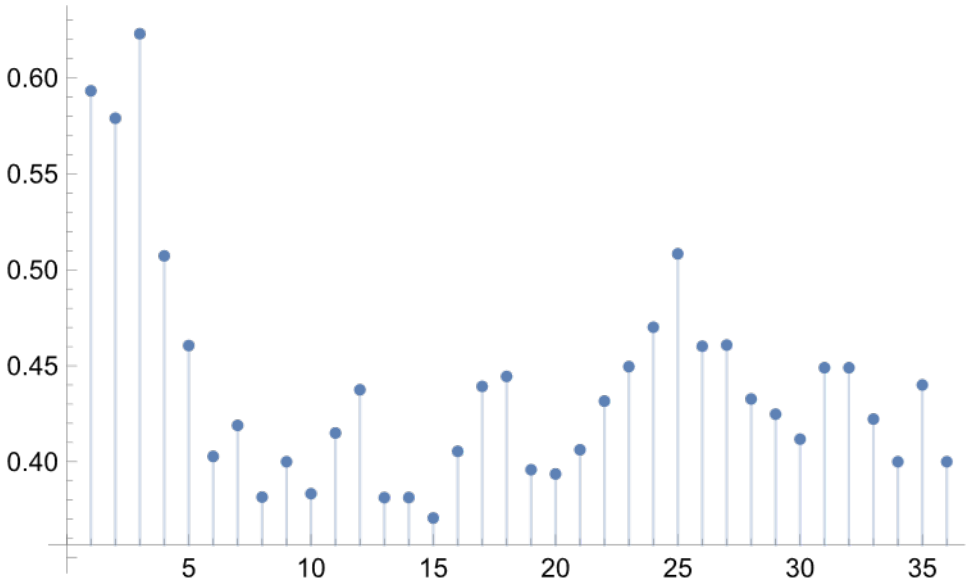

Figure 2. The percentage of women among UTA math graduate students since Fall 2005

In Figure 2 we show the percentage of women in the UTA mathematics graduate student enrollment since the fall of 2005. The number for Fall 2005 was 35 (59%) and the number for Spring 2023 was 28 (40%). During the Covid-19 pandemic, the percentage of women among the graduate mathematics students decreased from 42 in Spring 2020 to 28 in Spring 2023.

In Figure 3 we present the percentage of international students in the UTA Mathematics Department since the fall of 2005. The number for Fall 2005 was 12 (20%) and the number for Spring 2023 was 3 (4%). During the Covid-19 pandemic, the percentage of international

mathematics graduate students in our department initially sharply increased from 27 (26%) in Spring 2020 to 53 (59%) in Fall 2021, and then that number has sharply decreased. One logical explanation for such a sharp increase first both in the number and percentage of international graduate students in the UTA Mathematics Department and then a sharp decrease is the following. The US Education Department recently started excluding the field of mathematics among the areas of national need in the GAANN program, and hence the GAANN funding in our department is no longer available to support our domestic doctoral students. From Figure 3 we conclude that the percentage of our domestic mathematics graduate students was consistently steady with a mean of 75%. The loss of our GAANN funding has thus had a devastating effect on the enrollment of domestic graduate students in our department. The reason for a sharp decrease in the number of our international graduate students has been due to the fact that we have not enrolled any new international students in our mathematics PhD program because of travel restrictions and those existing PhD students successfully received their PhD degrees and moved to professional careers. In many mathematics PhD programs in the United States the international students make up the majority, and the pandemic has had a devastating effect on the enrollment of new international students in many PhD granting institution. From Figure 3, we clearly see the strong positive effect of the GAANN funding in our mathematics doctoral program.

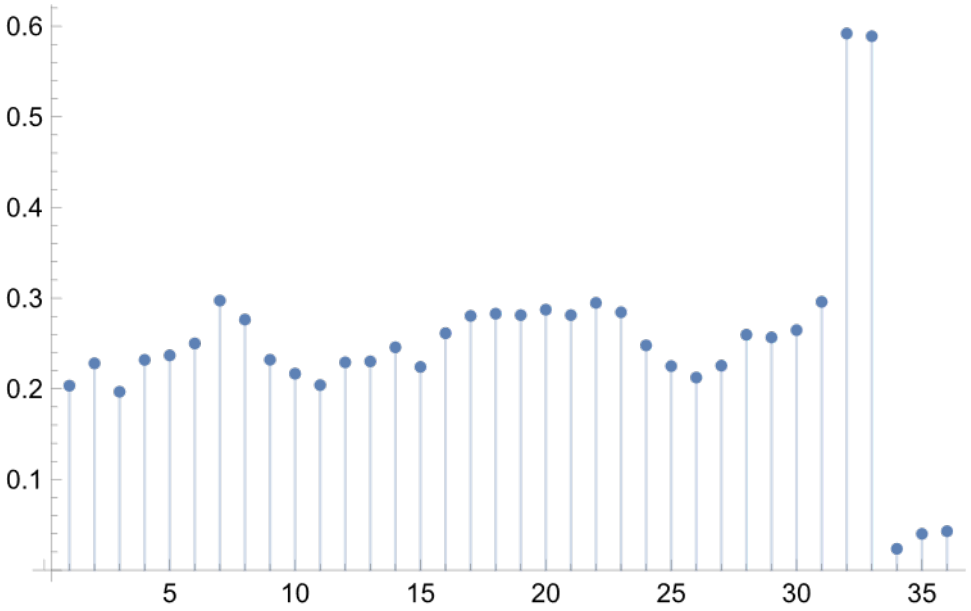

Figure 3. The percentage of international math graduate students at UTA since Fall 2005

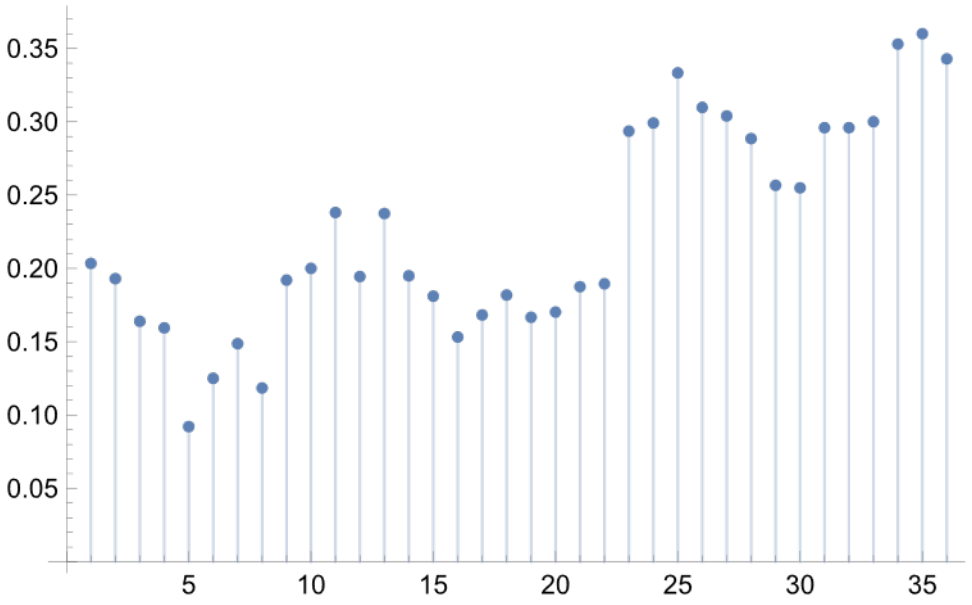

Figure 4. The percentage of URM math graduate students at UTA since Fall 2005

In Figure 4 we show the percentage of URM mathematics graduate students at UTA since Fall 2005. The percentage is obtained by dividing the number of underrepresented minority (URM) mathematics graduate students by the total number of mathematics graduate students. The number for Fall 2005 was 12 (20%) and the number for Spring 2023 was 24 (34%). From Figure 4 we observe that in recent years about 30% of our mathematics graduate students have been URM. During the Covid-19 pandemic, the number of URM graduate mathematics students has not changed much. That number was 26 (25%) in Spring 2020 and it was 24 (34%) in Spring 2023.

Figure 5 presents the percentage of URM mathematics graduate students at UTA among domestic mathematics graduate students since Fall 2005. The percentage is obtained by dividing the number of mathematics graduate URM students by the number of domestic mathematics graduate students. The number for Fall 2005 was 12 (26%) and the number for Spring 2023 was 24 (36%). During the Covid-19 pandemic, the percentage of URM graduate mathematics students among our domestic graduate students changed from 35% in Spring 2020 to 36% in Spring 2023.

In Figure 6 we present the enrollment of mathematics undergraduate students in the UTA Mathematics Department since the fall of 2005. The fall 2005 enrollment number was 102 and

the spring 2023 enrollment number was 163. During the Covid-19 pandemic, the number of our undergraduate mathematics majors has changed from 248 in Spring 2020 to 163 in Spring 2023.

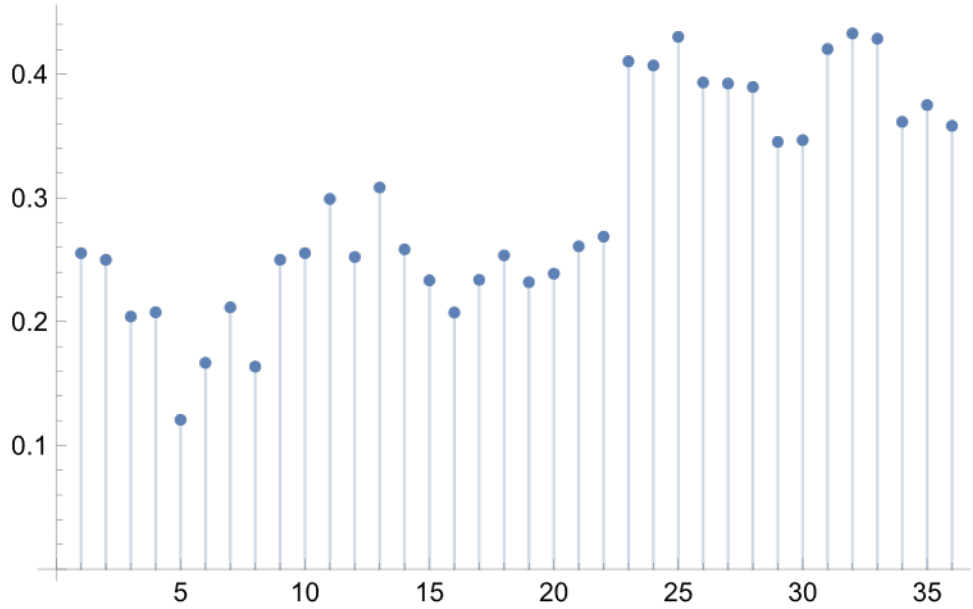

Figure 5. The percentage of URM domestic math graduate students at UTA since Fall 2005

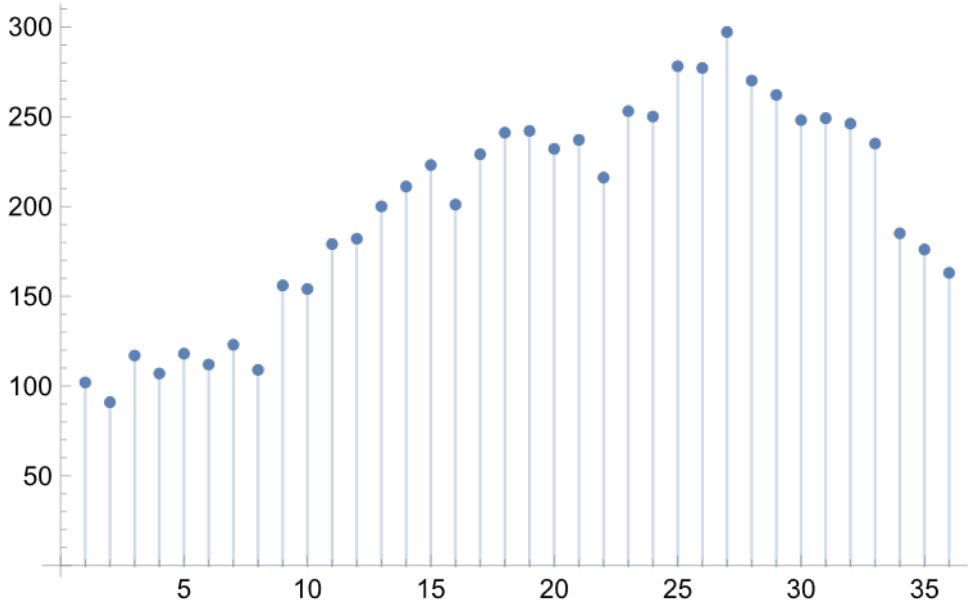

Figure 6. The UTA math undergraduate student enrollment from Fall 2005 to Fall 2021

In Figure 7 we present the percentage of women in the UTA mathematics undergraduate student enrollment since the fall of 2005. The number for Fall 2005 was 40 (39%) and the number for

Spring 2023 was 73 (45%). The percentage seems to be steady, but we are making efforts to increase the percentage of undergraduate women studying mathematics at UTA. During the Covid-19 pandemic, the number of our undergraduate women in mathematics has changed from 100 (40%) in Spring 2020 to 73 (45%) in Spring 2023.

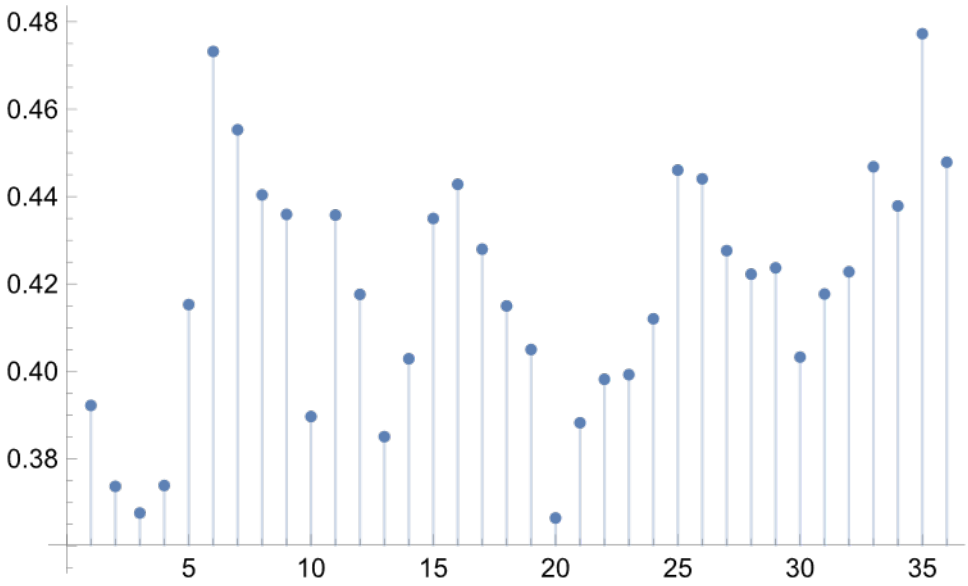

Figure 7. The percentage of women among UTA math undergraduate students since Fall 2005

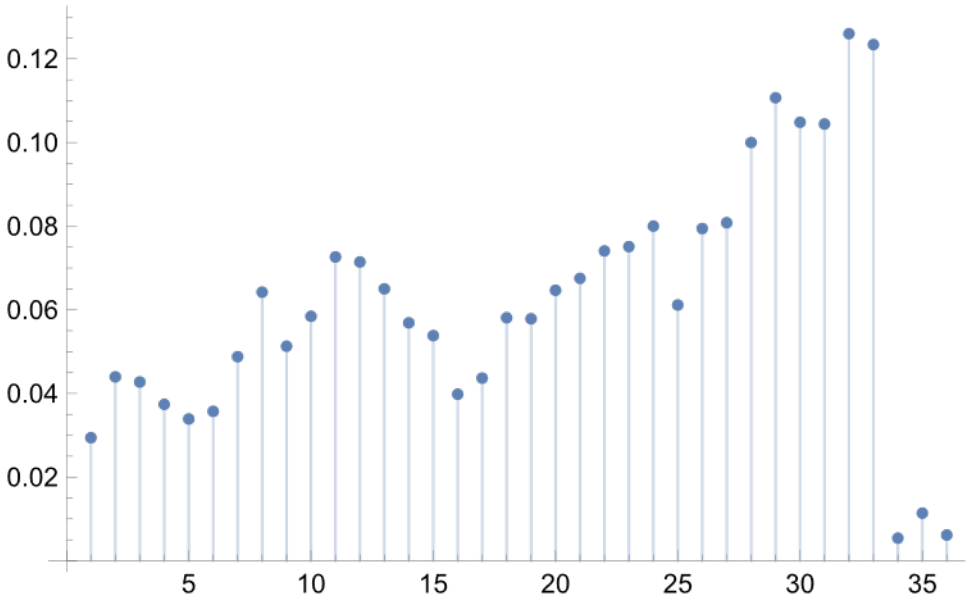

Figure 8. The percentage of international math undergraduate students at UTA since Fall 2005

In Figure 8 we present the percentage of international undergraduate students in the UTA Mathematics Department since the fall of 2005. The number for Fall 2005 was 3 (3%) and the

number for Spring 2023 was 21 (0%). The lack of available funding for international students at the undergraduate level is the main cause of the low percentage of international students at UTA, and this is also true in mathematics. During the Covid-19 pandemic, the number of our undergraduate international students in mathematics has changed from 26 (10%) in Spring 2020 to 1 (0%) in Spring 2023.

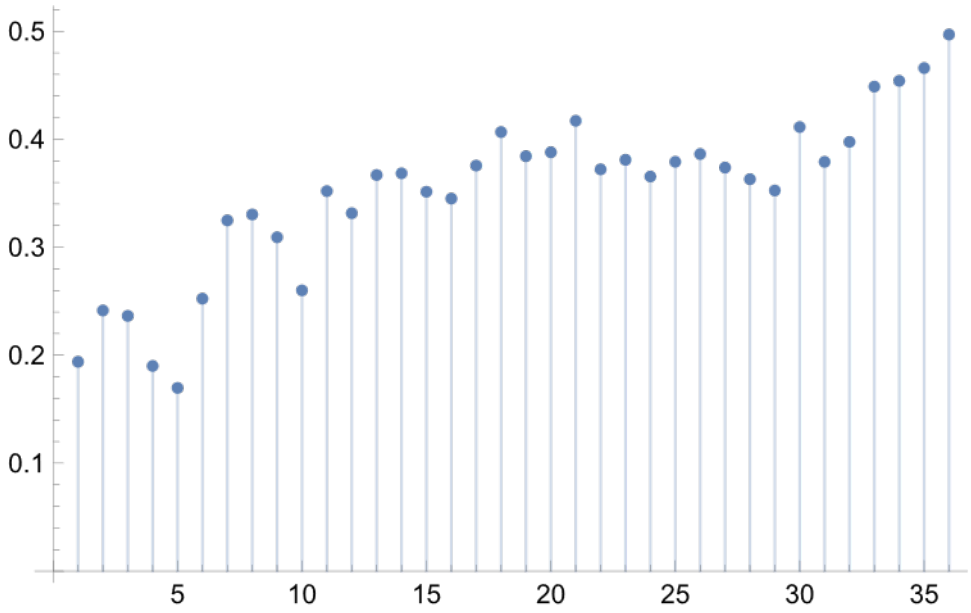

Figure 9. The percentage of URM math undergraduate students at UTA since Fall 2005

In Figure 9 we present the percentage of URM mathematics undergraduate students at UTA since Fall 2005. The percentage is obtained by dividing the number of URM mathematics undergraduate students by the number of mathematics undergraduate students. The number for Fall 2005 was 19 (19%) and the number for Spring 2023 was 81 (50%). As seen from Figure 9, the growth is steady. Our S-STEM grant supports a sizeable number of URM students and has been helping us to increase the number of URM undergraduate mathematics majors at UTA. During the Covid-19 pandemic, the number of our URM undergraduate mathematics majors has changed from 98 (41%) in Spring 2020 to 81 (50%) in Spring 2023.

In Figure 10 we present the percentage of URM mathematics undergraduate students at UTA among domestic mathematics undergraduate students since Fall 2005. The percentage is obtained by dividing the number of mathematics undergraduate URM students by the number of domestic mathematics undergraduate students. The number for Fall 2005 was 19 (20%) and the number for Spring 2023 was 81 (51%).

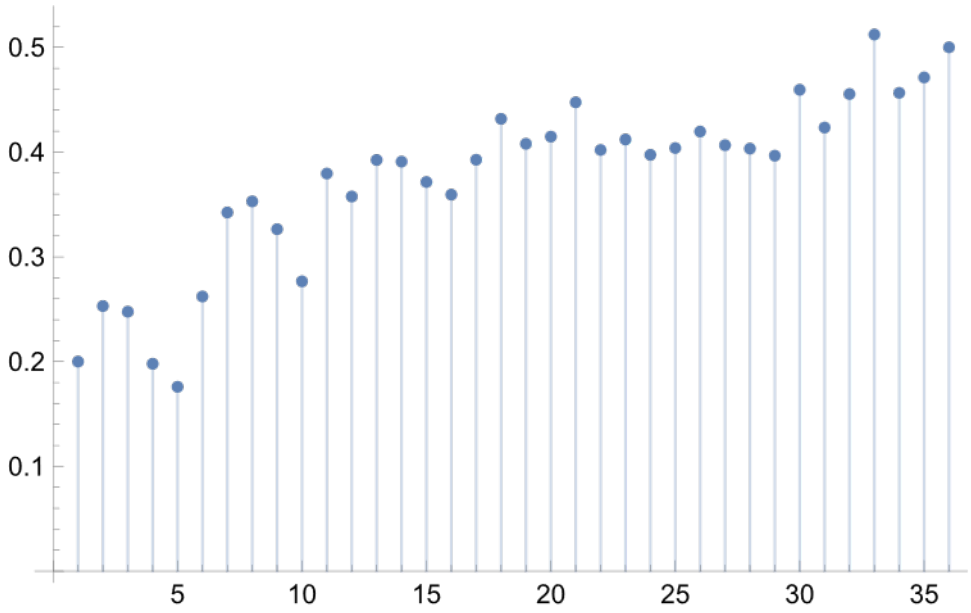

Figure 10. The percentage of URM domestic math UTA undergraduate students since Fall 2005

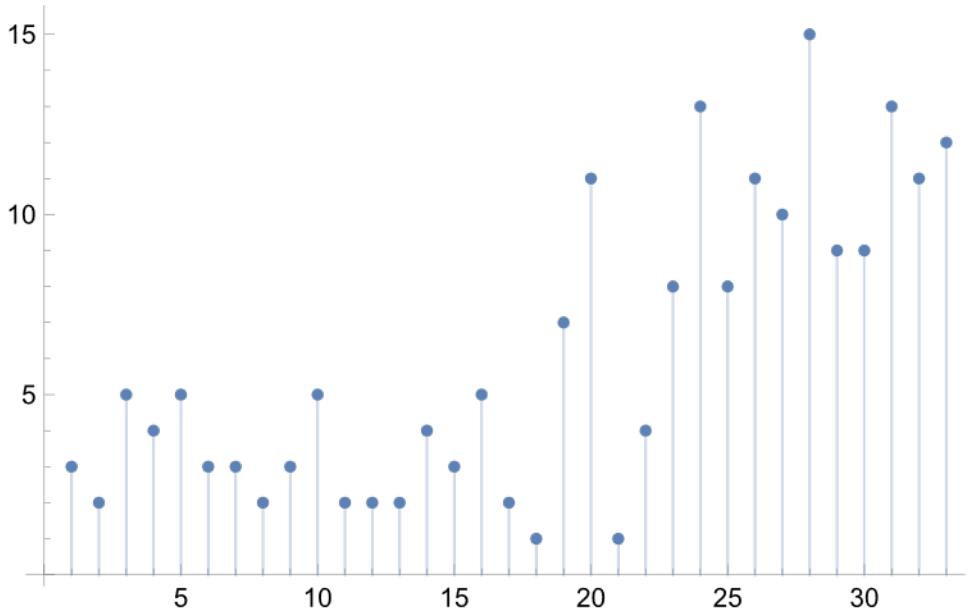

Figure 11. The annual number of math PhD degrees awarded UTA since 1990

In Figure 11, we present the annual number of mathematics PhD degrees awarded in the UTA Mathematics Department from year 1990 to year 2022. In the figure presented, the horizontal

axis shows 33 data points, where the point 1 corresponds to year 1990, the point 2 corresponds to 1991, the point 3 to 1992, etc. In particular, the point 5 corresponds to 1994, the point 10 to 1999, the point 15 to 2004, the point 20 to 2009, the point 25 to 2014, the point 30 to 2019, the point 31 to 2020, the point 32 to year 2021, and the point 33 to year 2022. There were 13 PhD degrees awarded in year 2020, 11 PhD degrees in year 2021, and 12 PhD degrees in year 2022.

UTA mathematics GR students	UTA UG mathematics majors
113 total (83 PhD and 30 master's students)	262 total
66% domestic, 34% int'l	89% domestic, 11% int'l
45% women, 55% men	49% women, 51% men
URM: 27% of all math GR students	URM: 29% of all UG math majors
URM: 42% of all domestic math GR	URM: 33% of domestic UG math

Table 1. The fall 2020 data for UTA mathematics students

UTA mathematics GR students	UTA UG mathematics majors
70 total (66 PhD and 4 master's students)	163 total
96% domestic, 4% int'l	100% domestic, 0% int'l
47% women, 53% men	45% women, 55% men
URM: 34% of all math GR students	URM: 50% of all UG math majors
URM: 36% of all domestic math GR	URM: 50% of domestic UG math

Table 2. The spring 2023 data for UTA mathematics students

We compare the student enrollment data in the UTA Mathematics Department between the fall semester of 2020 and the spring semester of 2023. The effect of the pandemic is clearly seen from the comparison of the two tables.

4. THE DATA ON THE UTA MATHEMATICS S-STEM PROGRAM

The S-STEM program in the Mathematics Department at UTA has been running since the fall semester of 2008 and supported by three consecutive NSF-DUE grants. As of April 2023, this program has supported 155 distinct domestic undergraduate mathematics majors by providing scholarships (based on the demonstrated financial need) and mentorship. Most of our S-STEM scholars are usually supported during multiple semesters until they receive their bachelor's

degrees. Of these 155 supported students, 119 of them have already received their bachelor's degrees, 2 have quit without receiving their undergraduate degrees, and 34 are making timely progress toward their bachelor's degrees. We summarize the relevant data, current as of April 2023, about our S-STEM program in Table 3.

155 scholars supported	119 degree recipients	34 continuing
79 women (51%) 76 men (49%) URM: 57 (37%)	57 women (48%) 62 men (52%) URM: 40 (34%)	21 women (62%) 13 men (38%) URM: 19 (56%)

Table 3. The supported student data in the UTA Math S-STEM program during 2008-2023

In Figure 12 we present the average GPA in the scale of 4.00 for our S-STEM scholars, as a bar chart, in the last four years, starting with Fall 2018 ending in Spring 2023. The bar chart indicates that our S-STEM scholars' average GPA has been around 3.45 out of 4.00.

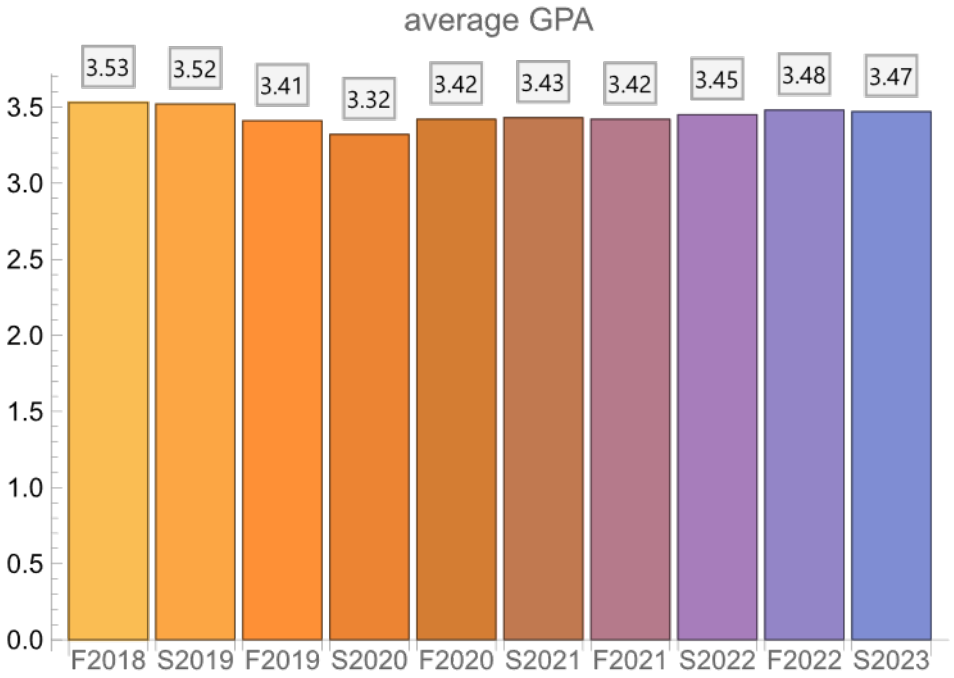

Figure 12. The average GPA for UTA Math S-STEM scholars since Fall 2018

In Figure 13 we present the average number of hours per week our S-STEM scholars worked for off-campus employment in each of the academic semesters beginning Fall 2018 and ending in Spring 2023. Without pressuring them, we encourage our scholars to reduce the number of

weekly hours spent on off-campus employment. It is often the case that their S-STEM scholarship is not sufficient to meet their financial need, and they work to have additional income to cover their housing, food, transportation, and other expenses. At times we are able to help them find some on-campus academic employment such as tutoring in the Math Clinic in our mathematics department for additional income. Our S-STEM scholars closely interact with our undergraduate mathematics advisor so that their academic workload every semester is compatible with their number of off-campus employment hours per week. This is something that we have learned over the years in running our S-STEM program, and this is one of our best practices recommended to other directors running S-STEM scholarship programs. The number of weekly hours for off-campus employment varies depending on the individual scholars, and hence it is crucial that each S-STEM scholar's academic course load and off-campus employment hours must be checked and made compatible with each other every semester. During the Covid-19 pandemic, initially our scholars increased their weekly work hours but later reduced those hours, perhaps because of various types of financial help provided to the needy by the federal government during the pandemic.

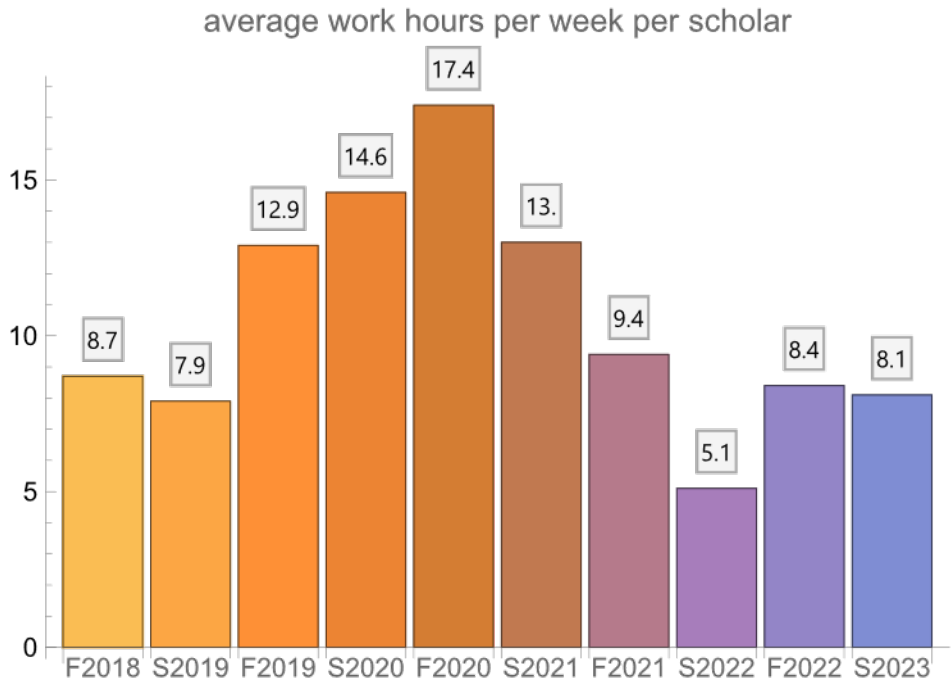

Figure 13. The average weekly work hours for UTA Math S-STEM scholars since Fall 2018

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