Board 406: The Transformation of a Mathematics Department

Prof. Tuncay Aktosun, The University of Texas at Arlington

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 was the GAANN Fellowship Director in his department during 2006-2022, he has been 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.

Dr. Yolanda Parker, Tarrant County College District

Dr. Yolanda Parker's education includes earning a Bachelor of Science from Texas A&M University in Applied Mathematical Sciences, a Master of Arts in Liberal Studies from Dartmouth College (New Hampshire) and a Ph.D. in Mathematics Education from Illinois State University. She 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 is a contributing author for the books A Commitment to Teaching: Toward More Efficacious Teacher Preparation; The Brilliance of Black Children in Mathematics: Beyond the Numbers and Toward a New Discourse; and Mathematics Teaching, Learning and Liberation in the Lives of Black Children. She is a co-author for the books Engaging in Culturally Relevant Math Tasks: Fostering Hope in the Elementary Classroom and Engaging in Culturally Relevant Math Tasks: Fostering Hope in the Middle and High School Classroom.

Prof. Jianzhong Su, The University of Texas at 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

The Transformation of a Mathematics Department

1. INTRODUCTION

In this paper we describe the deliberate efforts made since 2005 to transform the Mathematics Department at the University of Texas at Arlington (UTA). The efforts have been aimed at making the Department a better place for our faculty, staff, and students. Our main motivation has been to create a good environment for us all. During the process we have learned some good lessons and found some good practices to share with others.

A positive aspect of UTA is its location. Our campus is in the Dallas-Fort Worth metroplex (the DFW metroplex), which has the densest metropolitan population in Texas as well as in the Southern United States. The DFW metroplex is also called the Dallas-Fort Worth-Arlington metroplex because Dallas, Fort Worth, and Arlington are the three largest cities in the DFW metroplex, with the respective populations of 1.3 million, 1 million, and 400 thousand, according to the 2020 census. In fact, the population of the DFW metroplex is over 7.6 million, which is the fourth largest in the United States. According to the 2016 census, the DFW metroplex had the fastest population growth in the United States.

The DFW metroplex has a diverse and strong economy, including many sectors such as banking, commerce, defense, energy, healthcare, insurance, medical research, technology, telecommunications, and transportation. It employs many STEM professionals with good salaries, and it has the highest concentration of higher education institutions in Texas. The strong economy, the presence of skilled workers, the local training of STEM workforce, and the availability of good STEM jobs make the DFW metroplex an attractive place to live and raise a family, and our university naturally benefits from its location.

In 2005 the UTA Mathematics Department started hiring several tenured full professors, and this was one of the primary factors enabling the transformation of the Department. In most universities, the faculty hiring in a typical mathematics department takes place at the level of tenure track assistant professor. This usually does not lead to a transformation of the department. The newly hired faculty member usually blends in, learns to live in the existing academic culture, and becomes a part of the existing system. Thus, the status quo is maintained, and no transformation takes place in the department. The hiring of several tenured full professors in the UTA Mathematics Department enabled a strong collaboration among the newly hired full

professors and the other full professors, who aspired a transition but could not succeed due to a lack of critical mass of faculty to initiate a transformation in the Department. The newcomers brought fresh ideas and fresh blood to the Department, and the old timers knew the areas needing improvements. The common desire prevailed to transform the Department into a nice place for all faculty, staff, and students. The misconceptions, unnecessary rivalries, exclusions, undesirable traditions, and other negative aspects in the Department started disappearing, and the transformation started taking place.

2. INCLUDING EVERYONE IN THE COMMUNITY

A wise mathematician was once asked the following question: "In a typical mathematics department in the United States there are all these talented faculty members who are excellent in their own individual teaching, research, and other endeavors. Why is it the case that the department itself is not as strong as the sum of the strengths of the individual faculty members?" The wise mathematician's answer was the following: "A mathematics department is like a horse carriage, and the faculty members are like the horses drawing the carriage. If all the horses move in the same direction, then the carriage also moves in the same direction with a good speed. On the other hand, if the individual horses try to move the carriage in different directions, then either the carriage does not move or moves very little." The answer also makes sense mathematically. The vector addition of very strong forces can result in a zero net force or a very small net force. Without the collaboration of a critical mass of full professors in a mathematics department, it is difficult to transform the department. Our department was very lucky that such a collaboration took place starting in the fall semester of 2005.

It is unfortunate that the standard atmosphere in a typical mathematics department in many higher education institutions favors individual accomplishments rather than the accomplishments of the department itself. It is equally unfortunate that individual faculty members in a typical mathematics department spend a lot of time trying to document their individual accomplishments so that they would get individual recognition promoting themselves compared with others in the department. Such an award system based on the zero-sum game mentality results in rewarding some in the department at the expense of the rest. Such institutions do not realize that synergy and cooperation among faculty and staff can yield stronger accomplishments for the department itself, and the cooperation can result in bringing a lot of external resources into the department.

There is no longer a zero-sum game, and the external resources can be shared by everyone in the department, without creating any injustices. It is also unfortunate that at times the credit for a strong accomplishment by a mathematics department would go to one individual or a few individuals rather than everyone in the department. Unless all the members in a department feel that they are included in sharing the credit, the transformation cannot be institutionalized or cannot be maintained.

The motto of the University of Texas at Arlington is "be a maverick!" Unfortunately, the implication is that accomplishments can only come from "strong individuals" and the "real work" can be performed only by "strong individuals." How nice it would be to change that motto to "don't be a maverick, be a horse instead!" This is because real work is not performed by mavericks but by horses, the mavericks usually get the credit for the work accomplished by the horses. The incentives that drive the horses are the true benefits for the whole community, and the incentives that drive the mavericks are the benefits for the individuals. Setting aside the maverick mentality and working as "horses," we ourselves were able to transform the UTA Mathematics Department for the benefit of our own faculty, our own staff, and our own students.

A department consists of faculty, staff, and students. Our own department works in harmony because we all realize that our accomplishments and successes are not due to a single individual or a particular group but are achieved by all of us working together. We function like a family. For example, we secure external funds to support our undergraduate and graduate students. In running our grant and scholarship programs, our staff members play a key role. Without them it is impossible to run those departmental programs. Our department functions well because everyone's contribution is acknowledged.

3. THE MATHEMATICS S-STEM PROGRAM

We started our S-STEM program [1] in the UTA Mathematics Department in 2008. We secured the grant support from the Division of Undergraduate Education (DUE) of the National Science Foundation (NSF), and as of February 2024, we have supported 157 undergraduate students, among whom 148 have already received their bachelor's degrees, 2 quit without a degree, and 7 are continuing in the spring semester of 2024. Four of those continuing students will receive their bachelor's degrees in May 2024. The remaining three will receive their degrees in May 2025. As seen from Figure 1, the number of our undergraduate mathematics majors started increasing after

we secured our first S-STEM grant in 2008. The number reached a peak in the fall semester of 2018. During the COVID-19 pandemic the number decreased from 248 in the spring semester of 2020 to 163 in Spring 2023. The decrease in the enrollment of undergraduate mathematics majors has been partly due to a change in the UTeach Program for mathematics majors on our campus to become mathematics teachers and the related teaching certification process. Clearly, we all need to work harder to maintain or increase the number of our mathematics majors.

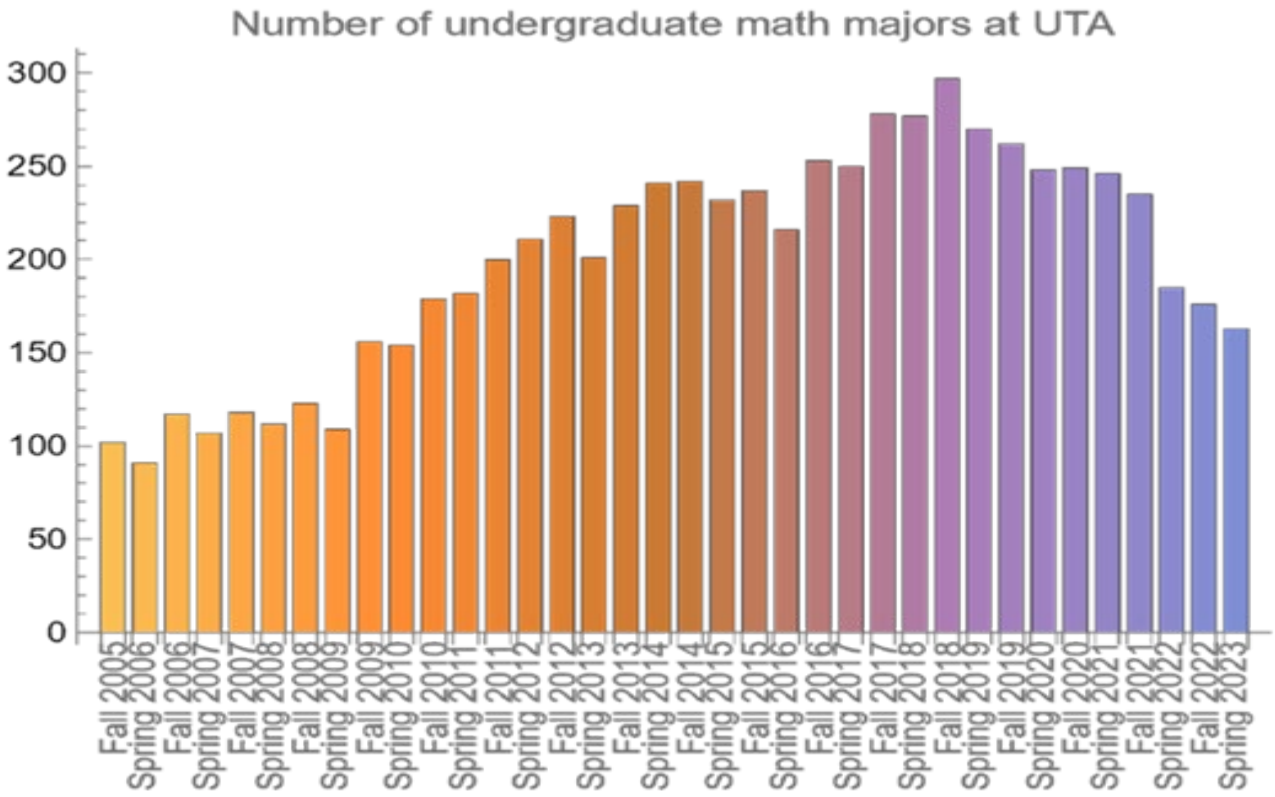

Figure 1. The number of UTA undergraduate mathematics majors from Fall 2005 to Spring 2023

The NSF S-STEM grants have enabled us to support mathematically talented low-income students based on their unmet financial need. Thanks to those NSF grants we have secured, we have helped many talented undergraduate students receive their bachelor's degrees and then either continue to graduate school or join the STEM workforce. We have used our S-STEM grants well to contribute to the regional and national economy as many of our scholars now have meaningful careers and most of them are also involved mentoring activities to help new generation of students to get degrees in STEM fields.

Over the years of running our S-STEM program, we have made various improvements benefiting both our scholars and the faculty and staff team in the Mathematics Department running the program. For example, we have drastically simplified the scholarship application process for the applicants, we have initiated an interview process for each applicant in the beginning of each semester before they are admitted or readmitted to the program, we have considered each applicant carefully and ensured that we do not miss any talented students who may have had a temporary setback during their academic studies, we have improved their academic advising so that they have the appropriate coursework toward timely graduation, we have made improvements to our regular meetings with the scholars so that they are more comfortable discussing their issues with our faculty mentors, we have invited previous scholars who have graduated to come and speak to our current scholars, we have provided undergraduate supervised research opportunities, we have encouraged our S-STEM scholars to be involved in various student chapters of active mathematics organizations in our department, we have helped them attend various S-STEM meetings and conferences, we have encouraged them to take part in outreach activities for area middle and high school students, and we have invited industrial mentors from the DFW metroplex area to talk about career opportunities for them.

The negative impact of the COVID-19 pandemic on our S-STEM scholars as well as all our undergraduate and graduate mathematics students was noticeable. To contain the spread of the virus, our classes had to be taught online during the period of March 2020-May 2021. During that period, we had to meet and mentor our S-STEM scholars only online. Even though we did our best to help our students cope with the negative effects of the pandemic, those effects still negatively impacted our students and included anxiety, sadness, dealing with isolation, lack of focus in learning, lack of physical activities, worrying about family members and friends, and developing some mental health problems. The pandemic also caused lower future enrollment.

4. THE MATHEMATICS GAANN PROGRAM

We started running our GAANN (**G**raduate **A**ssistance in **A**reas of **N**ational **N**eed) program [2] in the UTA Mathematics Department in 2006 by securing our first GAANN grant from the US Education Department. This is a need-based fellowship program. The several GAANN grants we have secured have allowed us to support 54 GAANN fellows, among whom 53 received their PhD degrees already and one fellow continuing with timely progress to the degree. The GAANN program has not only enabled us to award a large number of PhD degrees in our department, but

they have also helped us to improve the quality of our PhD program and increase the number of domestic PhD students in our department. Unfortunately, the US Education Department recently stopped considering mathematics and other basic sciences among the areas of national need. We hope that this will change in the future. In fact, there are some hopeful signs that the 2024 GAANN grant competition will be open to applicants from mathematics departments. We passionately believe that mathematics and other basic sciences help contribute greatly to ensure the global leadership of the United States and that the major developments concerning national defense and national security are initiated by advances in basic sciences.

5. THE MATHEMATICS BRIDGE PROGRAM

There are many talented undergraduate students who are interested in studying mathematics at the doctoral level, but many of them are underprepared for this endeavor. The underpreparation prevents them from enrolling in a PhD program with full financial assistance. Such underserved students usually come from low-income families, are mostly URMs (underrepresented minorities), and receive their bachelor's degrees in mathematics at colleges and universities where advanced undergraduate mathematics courses are usually not offered. Talent is equally distributed among all of us, and yet the percentage of the URMs receiving a PhD degree in mathematics is about 7.9% of the domestic PhD recipients annually. According to the 2020 census, the US population is 19.1% Latino and 13.6% Black, and the Texas population is 39.3% Latino and 11.8% Black. In fact, the Latino population percentage has now changed, and the Latinos make up the largest population group in Texas at 40.2%.

The gross underrepresentation in the percentage of mathematics PhD recipients among URMs was the motivating factor for us in 2016 to start our NSF Bridge-to-Math-Doctorate program in our department. With the funding we secured from the NSF and additional institutional funds, our program had the goal of preparing 30 underserved mathematics students for doctoral studies. Our NSF grant expired in 2022, but we continue and sustain the program with internal funding while looking for external funding to expand it. Our program so far has helped 54 Bridge scholars, and 95% of them have already moved to doctoral studies after their one-year participation in our program. Our program has the two-semester academic component to strengthen the Bridge scholars' academic backgrounds in Analysis and Advanced Linear Algebra and the summer component to involve them in supervised research. The program has a strong mentoring component, the Bridge scholars are treated like any other doctoral students, their

academic coursework is individually designed, their stipends and tuitions are covered, and they are also paid additional stipends in the summer.

The AMS (American Mathematical Society) honored [3] our Bridge program with the 2023 Mathematic Programs That Make a Difference Award. This award recognized our program for increasing the number of students from historically underrepresented groups who receive advanced mathematical degrees. The AMS added that our Bridge program "has documented success and is a replicable model." The AMS "commended our program for its success in bringing more persons from historically underrepresented and underserved groups to doctoral studies in the mathematical sciences, particularly Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), as well as URM faculty mentors within the Gulf States Math Alliance (GSMath). These mentors function as excellent recruiters for the Bridge Program and recommend their own students."

Our Bridge program also received some recognition from Excelencia in Education [4]. Half of our Bridge scholars have been Latino, and our program was nominated for Examples of Excelencia in the graduate category and was a finalist [5] in that category in 2023.

6. THE MATHEMATICS GRADUATE PROGRAM

In Figure 2 we present 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 period, the number of mathematics graduate students decreased from 102 in Spring 2020 to 70 in Spring 2023. Among the 70 mathematics graduate students in Spring 2023, only 4 of them were master's students and the rest were all PhD students. The decrease was mainly caused by the fact the number of incoming graduate students was less than the number of mathematics students receiving their PhD degrees in our department. The number of PhD degrees awarded in our department remained relatively high; namely, 13 in the year 2020, 11 in the year 2021, and 12 in the year 2022. In Figure 3 we present the annual number of mathematics PhD degrees awarded in the UTA Mathematics Department from the year 1990 to the year 2022. In the figure presented, the horizontal axis shows 33 data points, running from the year 1990 to the year 2022. For example, there were 13 PhD degrees awarded in the year 2020, 11 PhD degrees in the year 2021, and 12 PhD degrees in the year 2022.

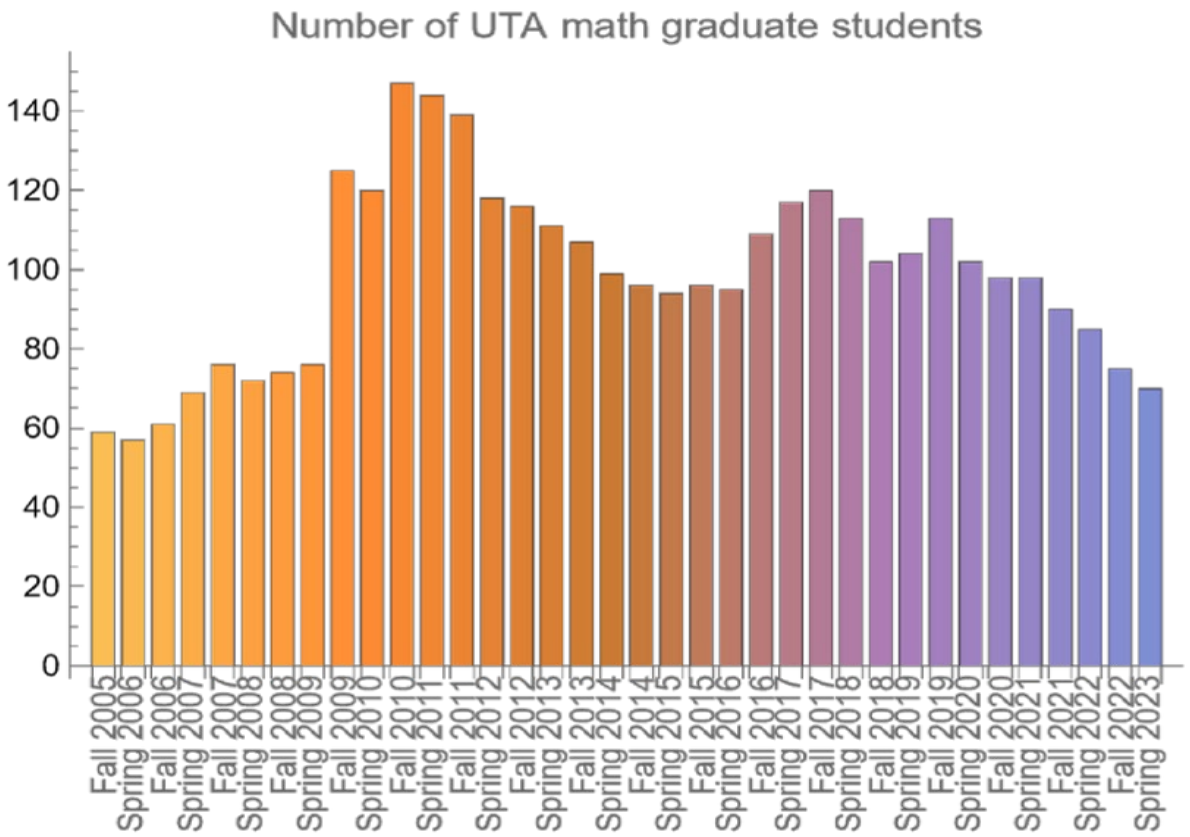

Figure 2. The UTA math graduate student enrollment from Fall 2005 to Spring 2023

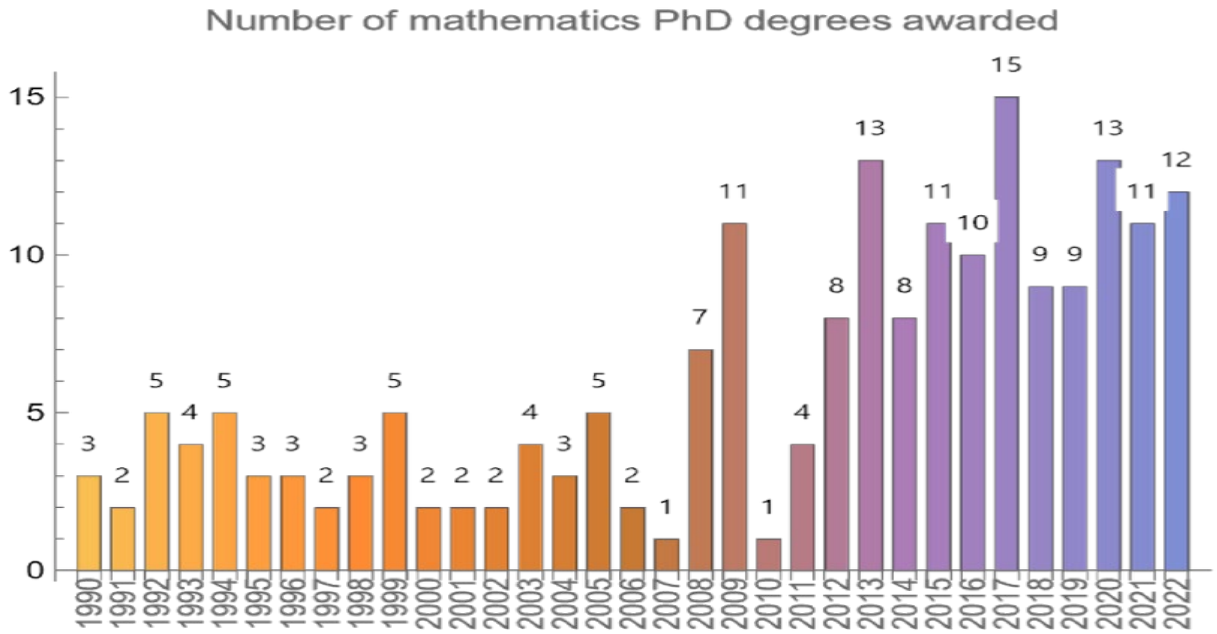

Figure 3. The annual number of math PhD degrees awarded at UTA since 1990

7. THE CONCLUSION

The deliberate changes we have made since 2005 in our department have positively affected our faculty, staff, and students. The external funding we have secured from various federal agencies has played a significant role in transforming our department for the better. There have been many improvements such as using our financial resources optimally but generously for student success; building a community and an environment where everyone feels comfortable and has a sense of belonging; understanding the true needs of our faculty, staff, and students; building good relationships with other mathematics departments in Texas, in the region, and in the nation; mentoring our students not only by faculty but also by staff, industrial mentors, and peer mentors; and initiating and supporting programs and activities benefiting our students.

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