Increasing Minority Representation in the Mathematical Sciences: Good models but no will to scale up their impact

Carlos Castillo-Chavez, Carlos Castillo-Garsow
Department of Mathematics and Statistics
Arizona State University
chavez@math.asu.edu
cwcg@asu.edu

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1 Abstract

There are plenty of well-established misconceptions in the mathematical sciences, broadly speaking to include the applied and pure mathematics, statistics, computer science and the computational sciences communities across our nation, that are used to justify the problem of under-representation of US Latinos, Native Americans and African Americans in the mathematics professoriate. The most prevalent explanation puts the key as far away from the university communities as it can possibly be done. The problem of under-representation is unsolvable within our life time because of the shortcomings in the mathematics education that is provided at the $K-12$ levels. "Until these issues are resolved there is nothing that we can do". This self fulfilling prophecy ignores the history of cumulative successful efforts carried out by long-term *university partnerships* over the past two decades through funded projects like the Louis Stokes Alliance for Minority Participation (LSAMP). Programs like LSAMP, IGERT and VIGRE, funded by the National Science Foundation, have dramatically increased the pool of US students (minorities and non-minorities) with bachelors degrees in STEM (Science, Technology, Engineering and Mathematics) fields while providing significant resources for Ph.D. training for US students at the graduate level. In this essay, I discuss the framework that we have used to increase US minority representation in the mathematical sciences in the context of this pattern of misconceptions over the past decade. It is shown that changing the current landscape can be done over a relatively short time scale. This framework is presented as *one* model capable of altering the disgraceful diversity landscape in which the the mathematical sciences live. The model illustrates *the obvious* that is, that the current system of exclusion, regardless of the reasons and our past history, can be changed as long as it is treated as a true national priority. We live in a society that *continuously* reinvents itself in the presence of new challenges! So why can't we find a systemic solution to the problem of inequity and under-representation in academia?

2 Mathematical Theoretical Biology Institute

2.1 A Little Bit of History

William Yslas Velez[1] while President of the Society for the Advancement of Chicanos and Native American in Science challenged me[2], as a faculty at an Ivy League Institution[3], to find ways of increasing minority representation in the mathematical sciences. Bill[4] who is a very serious man, had a plan for me. So he immediately connected me with Jim Schatz[5] whose concern for the the diminished or lack of participation of *all* Americans in the mathematical sciences is unparalleled. So, with the advice of Bill and the encouragement of Jim, I put a draft of a plan that would develop a mentorship model that to would be tried at a *Hispanic Serving Institution*, if possible in the summer of 1996. This was the basis of the grant proposal that would be eventually sent to NSA. I had just visited the University of Texas el Paso as a part of a NSF site visit team. During my visit, I was impressed by the commitment to diversity expressed by its President Diana Natalicio. So I approached a young outstanding statistician, Javier Rojo[6] who immediately supported our efforts and together we began to plot how to make his university a national model for the training of US underrepresented minorities in the mathematical sciences. Soon there after, Bill introduced me to a young mathematician, Herbert Medina[7] with strong interests in undergraduate education and diversity and encouraged me to bring him on board. So the three of us submitted a NSF proposal to support 10 additional students (the same number that would be funded by NSA). Unfortunately, the Mathematics Department at the University of Texas el Paso did not find our model compelling so we failed to establish a program at this Hispanic Serving Institution. With the NSF grant deadline less than 24 hours away, I had no option but to call my provost, Don Randel[8] to inform him of our failure and ask him for advice. Don immediately provided the economic support to get this effort started and proceeded to encourage me to step up our efforts in this direction. It is at this point, that the Mathematical and Theoretical Biology Institute (MTBI) was established with the strong institutional support of the Office of the Provost at Cornell University, a program that since 2004 has been

[1] Bill's concern for the future of young American mathematicians, particularly Chicanos, comes from the moral fiber and determination of individuals who like Bill will not give up on their construction for a community that is based on fairness and opportunity for all

[2] Carlos Castillo-Chavez

[3] I was member of Cornell University faculty from 19988 to 2003 where I was a member of the graduate fields of applied mathematics, biometry, epidemiology, ecology and evolutionary biology, statistics and theoretical and applied mechanics

[4] Bill is a distinguished professor of mathematics at the University of Arizona, a recipient of a White House Award for his documented efforts to mentor and support minority students

[5] At that time, Jim was the Chief of the Division of the Mathematical Sciences at NSA

[6] Javier Rojo moved a few years later to Rice University where he currently leads one of the premier undergraduate research programs in statistics. At Rice, he is changing the graduate student landscape in the statistical sciences

[7] Herbert Medina collaborated in this project in 1996 and spent 1997 co-building a similar program, SIMU, but with emphasis in pure mathematics. Herbert Medina and Ivelisse Rubio's program made tremendous measurable contributions to the training of minority students in the mathematical sciences from 1998 to 2002 from its base at the University of Puerto Rico in Humacao.

[8] Don left a few years later to become the twelfth president of the University of Chicago, a position that he just left after six years to become to President of the Andrew W Mellon Foundation

enthusiastically and effectively supported by the Office of the Provost at Arizona State University.

2.2 The Mathematical and Theoretical Biology Institute or MTBI: a brief perspective

The goal of MTBI's programs is to increase the number of underrepresented US minorities with doctorates in the mathematical sciences or related fields. In line with my own scientific interests and the growth of the field of mathematical biology, this effort is being carried out within a research and mentorship institute that fosters and instigates innovation at the interface of the mathematical, social and natural sciences. The almost total absence of US Latinos, Native Americans and African Americans in the mathematical sciences nearly at every institution, made it imperative that we establish a national research mentorship program of the highest standards that would create the national pool, that is, the critical mass of highly qualified students needed to increase the *national* number of Ph.D.s in fields where mathematical, computational and modeling skills play a critical role.

MTBI's summer research experiences provide the skills and support required to develop the confidence needed to succeed in graduate school in a collaborative learning environment that aims also to train future scientific and academic leaders – an area where minority representation is dismal.

MTBI's recruitment efforts are time consuming but doomed to be successful because there is a *large pool* of underrepresented minorities enrolled in the mathematical sciences at private and state institutions across the US. Obviously, we have large educational lapses and outright failures at the $K-12$ level and the losses of talents at this level, particularly among underrepresented US minorities, are simply shameful. However, we can't wait for *somebody* to solve systemic educational problems at the $K-12$ level before we take on the responsibility of tackling these issues at the level where we, college professors and administrators, can contribute immediately.

It would not be a *monumental task* to increase *dramatically* the representation of US citizens and residents, particularly underrepresented minorities and women, in *all* graduate programs in the mathematical sciences *today* by any stretch of the imagination. There are plenty of case studies and models that prove that such an effort would be doable and relatively inexpensive. It is unacceptable to continue to use arguments whose only goal seems to justify a record of failures in the mathematical sciences over the past four decades. The scientific American enterprise is not known for arguments that justify failure. Why have arguments that justify such failure become the norm when it comes to issues of under-representation in STEM fields?

2.3 MTBI: a brief look at the numbers

For eleven years ($MTBI$) has mentored *through its sequential summer research experiences* a diverse group of undergraduate students (277) that includes a high percentage of underrepresented US minorities. MTBI brings *primarily* juniors or seniors from *mostly* "non-selective" colleges and universities who may not have considered graduate school as a real possibility in their future. MTBI participants have either a solid, very good or outstanding academic record. Most if not all applicants have a clear desire to find out what role if any mathematics plays in solving problems of importance to our society.

MTBI summer program has been a contributor to the establishment of successful minority graduate communities of students at the University of Iowa[9], Cornell University and Arizona State University. MTBI alumni have helped these institutions establish and maintain a critical mass of US underrepresented minority students in their graduate programs. MTBI has also sent a small number of minority graduate students to equally outstanding universities. The list includes Harvard, Princeton, Stanford, Michigan and other equally recognized institutions. The first "large" crop of MTBI alumni has just completed their Ph.D. degrees in the mathematical sciences. They are entering the scientific enterprise primarily through the postdoctoral route. Their numbers however small represent a significant perturbation of past steady states. In 2005, MTBI alumni received 10 Ph.D.s in the mathematical sciences, 7 of which were awarded to members of underrepresented minority groups. Seven hold postdoctoral positions (including six underrepresented US minorities) at selective institutions and one a tenure-track faculty position in Puerto Rico. The 2005 class of MTBI Ph.D.'s includes four "Latinas" and one African American woman.

2.4 Increasing diversity in the sciences

The first step in achieving the goal of MTBI/SUMS [10] is to increase the number of under-represented minorities in the mathematical sciences at the graduate level.

MTBI/SUMS has sent 130 students from *underrepresented minority groups* to graduate school over its *first ten years*[11] and a total of 169 students overall. Furthermore, 52% have been females, including 65 from minority groups.

In the years 2001 and 2002, prior to MTBI/SUMS producing Ph.D. graduates, the U.S. awarded an average of 10 Ph.D.s to Latinos[12]. MTBI/SUMS efforts have significantly increased the national rate of production of U.S. Ph.D.'s among underrepresented minority groups. In 2005, MTBI/SUMS alumni received 10 Ph.D.s in the mathematical sciences, 7 of which were awarded to members of underrepresented[13] US minority groups. This is almost *a fourth* of the national total output for that year. Of those, 6 were Latino, *one third* for that year (6 out of 18). Of the 10 total MTBI/SUMS alumni Ph.D. graduates in 2005, 7 (six underrepresented US minorities) took on prestigious postdoctoral positions. The remaining minority student became an Assistant Professor at

[9]A note of clarification is in order, although MTBI is proud to have provided with a large pool of US minority applicants to the department of mathematics at the University of Iowa, the fact remains, that most if not all of the credit should go to its faculty and leadership who have welcomed, mentored, supported and graduated these students.

[10]The Institute for Strengthening the Understanding of Mathematics and Sciences or SUMS, its MTBI's partner institute and both merged in 2005. SUMS is the winner of a 2003 *Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring*

[11]This number does not include the admission to graduate school of members of the summer of 2006 MTBI class. However, we are to a good start. eight MTBI/SUMS alumni from the 2006 class will be attending graduate school in the fall of 2006 or the Spring of 2007.

[12]The data for national Ph.D. graduates was obtained from the AMS notices http://www.ams.org/notices/200602/05firstreport.pdf

[13]US Residents who are Latino (the overwhelming majority are Mexican Americans or Chicanos and Puerto Ricans but there are some whose heritage is from Peru or El Salvador) or African-American or Native Americans.

the University of Puerto Rico, Mayaguez campus. Looking at female graduates, MTBI helped produce *one third* (5 out of 15) of the total female underrepresented minority groups for 2005. Four of those five were Latinas, over half of the national production (4 out of 7).

MTBI/SUMS alumni are incredibly prolific, they have coauthored 111 technical reports over the past eleven summers. These reports are often continued or extended during the academic year. Several reports have served as instigators of highly innovative research. The bibliography includes a list of 10 *recent* refereed publications where MTBI alumni played a fundamental role. This collection of articles is but a fraction of the research instigated by MTBI/SUMS over the past decade.

Although this is a longer term and more ambitious goal, the indicators of success are visible. Twenty-four MTBI alumni have enrolled in a mathematical sciences program at Cornell University, MTBI's previous host school. Current data strongly suggest that about *ninety percent* of MTBI alumni who enrolled in a Ph.D. program[14] will complete their Ph.D.s at Cornell University. The mathematics department at MTBI's current host school of Arizona State University includes 24 US Latino and 5 African-American graduate students, of this group, 24 are also MTBI alumni. The total number of MTBI alumni at ASU is 34. In addition, fourteen underrepresented minority students who are MTBI alumni have enrolled in a mathematical sciences program at the University of Iowa[15] as well as several MTBI alumni who are not minorities. These large groups of MTBI alumni with a common experience form the nuclei of a community of minority scholars at three research institutions. MTBI alumni know each other, get together at annual professional meetings and have created a network that will seriously impact the training of future mathematicians, particularly those from underrepresented minority groups.

MTBI/SUMS follows an integrated approach that begins at the high school level. MTBI/SUMS has mentored 2,095 high school students through its Mathematics Science Honors Program (MSHP). Sixty percent of the student participants have been female, while *Hispanic and Native American students account for the largest ethnic minority group percentage, at fifty-one and eighteen percent, respectively.* Thirty-one percent of the students who participated in MSHP attended two or more summers consecutively, earning up to twelve credits in the three summers prior to attending ASU as freshmen. Almost sixty percent of MSHP participants have attended ASU after high school graduation. There are currently over 350 MSHP students attending ASU, with fifty-six female students and forty nine percent Hispanic students representing the largest gender and ethnic group respectively. The Ira A. Fulton School of Engineering has the highest percentage of enrolled MSHP students at thirty four percent, followed by the College of Liberal Arts and Sciences at twenty four percent. Students who participate in MSHP tend to have higher grade point averages and retention rates than those who did not participate in it. The standard grade point average (GPA) for a current non-MSHP ASU student is 3.01 while the average GPA for a current MSHP ASU student is 3.15.

Four Presidential Award for Excellence in Science, Mathematics and Engi-

[14] two students enrolled in MS programs and had no plans to complete a Ph.D.; one did not complete a Ph.D. because a serious family problem

[15] Its mathematics department is a winner of a 2005 Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring

neering Mentoring have been associated with MTBI/SUMS. The first (1996) to the late Joaquin Bustoz Jr, founder of SUMS, the second (1997) to Carlos Castillo-Chavez, Director of MTBI/SUMS, the third (1998) to Armando Rodriguez, Professor of Electrical Engineering and a strong contributor to MTBI/SUMS and the fourth (2003) to SUMS itself.

MTBI/SUMS alumni are beginning to take on faculty positions and evidence of future patterns of secondary recruitment have begun to emerge. The establishment of the *Applied Mathematical Sciences Institute, http://www.amssi.org/* by MTBI alumni Erika Camacho and MTBI graduate mentor and former summer Director Steve Wirkus in 2005, provides a vivid example.

This article articulates some of the elements of *MTBI*'s successful model in an attempt to demystify the mechanisms behind its successes. We hope that the portability of *MTBI*'s model is *obvious* but as most good efforts, requires the participation of committed individuals and the resources and support of agencies, foundations and university administrations. More importantly, it requires the will of the mathematics communities which will not become a major instigator of enduring change until this effort becomes a national priority. The US has *never failed* at recruiting committed individuals capable of carrying out *successfully* an effort that is considered to be in the *best* national interest. The major roadblocks lie on our inability to accept that under-representation is a major national priority whose solution deserves the long-term commitment given to similar national challenges. There are effective models whose implementation would instigate the required innovation that will result in the solution of problem of under-representation. Unfortunately, our national leadership (political and academic) has yet to show the will to support the implementation of the large scale solutions that we *know* will do the job. Thinking "big" and offering successful systemic approaches is not highly supported when it comes to addressing the issues of under-representation at the highest levels in the mathematical sciences. This is quite in contrast to the *standard* policy of recommending and encouraging the support of the most successful scientific projects.

Why don't we face these challenges head on? Part of the issue lies on the perspectives and vision of scientists who recommend funding decisions. Membership in academia *automatically* qualifies an individual as an *expert* in the development, implementation and evaluation of models designed to address our tragic educational shortcomings in the recruitment and retention of Americans (at the graduate level) in the *mathematical sciences*, regardless of the individuals' own mentorship records or history. A large percentage of this last group believe that the problem is "easy" to solve, or that it is not a problem (graduate schools have enough foreign students), or that students that do not come from elite programs should not go to graduate school ("natural selection"). Furthermore, many can't differentiate between US minorities and foreign nationals and the consequences of creating a society where about one third of the US population has no representation and, consequently role models and champions, in the US academia. Let's try to imagine today a university system with no women!

3 Model description

This section includes parts of a similar section of an article entitled "The New American University: Mentorship in the Mathematical Sciences," coauthored by us that will be published in a volume of contributions of "Models that Work" that will be published by the *American Mathematical Society* with the proviso parts of this model section can be used in this manuscript.

3.1 Common laguage

Students are assumed to be at least familiar with elementary calculus (2 semesters); have been exposed to linear algebra (eigenvalues and eigenvectors); have some "feeling" for probability, basic statistics (probability densities and distributions, random variables, Baye's theorem and expectation), birth and death stochastic processes, and some familiarity with a programming language. However, the cooperative nature of the MTBI environment is such that some weaknesses in these areas is not a critical problem. The first three weeks of the program are devoted to the study of dynamical systems in the context of ecology, epidemiology, immunology and conservation biology.

Furthermore, students learn thorough carefully prepared computational laboratories on how to program in *Matlab* (The Mathworks Inc.) and *XPP* while becoming proficient with *Maple*, *Minitab* and LaTeX.

The students are responsible for sixteen extensive complex sets of problems that are closely tied in to the lectures. "Review" lectures are provided on the essentials of linear algebra and probability. The preparatory phase ends with a pre-project that forces the students go beyond the material covered in class. Typically, the pre-project involves the study of a dynamical system with identified dynamics at two highly distinct temporal scales. Bifurcation analysis, simulations and the interpretation of model results are at the heart of this exercise.

Students are involved in lectures, problem and modeling sessions and computational labs for an average of five hours per day.

3.2 Salt and pepper

Relevance seems to be the key to motivation and success. A modeling seminar is conducted twice a week by program alumni (undergraduate and graduate students). Alumni describe the process that they followed as participants in identifying and selecting their own project as well as in convincing a group of colleagues (three to four) to join efforts. Alumni put emphasis on identifying a key question; a process that precedes the selection of the appropriate modeling framework. Students have often encountered difficulties when they insisted on using a specific methodology without taking into consideration its appropriateness for their question.

During the first weeks, distinguished researchers provide sets of two-to-three 90 minute connected lectures which are supplemented with relevant problem sets. These lectures highlight interesting "pure" mathematics or non-trivial applications.

Throughout the process students are continuously assisted by graduate students and resident faculty while they are encouraged to describe their work together.

Following the general "Oberwolfach"[16] mathematical model, the lectures,

[16]Oberwolfach, located in southern Germany, is one of the most famous retreats where mathematicians get together to exchange ideas in an environment that, by design, facilitates

seminars and talks are followed by a community dinner where students are encouraged to interact with faculty and graduate students. Paper table cloths serve a double function, that is, they are also used as a writing or drawing pads-napkins are not sufficient in these learning communities.

3.3 Absence of hierarchies

By design, the research agenda of this summer institute is set by the undergraduate participants. This tradition was begun in 1997 when the institute was in its second summer. Today, it is not uncommon to see students arrive with their own projects at the beginning of camp. Such students spend most of their first three weeks trying to sell their projects to two to three additional participants. There are no rules regarding the formation of such groups except that they should include three to four individuals. Once the groups have been formed (no faculty supervision) students begin to present orally their projects to a group of faculty and graduate students. The initial role of these sessions is to help students narrow the scope of their project. That is, efforts to identify a doable question are at the heart of these sessions where no effort is conducted to alter the overall goal of the students project. Typically initial suggestions are: What is the impact of alcohol on brain activity? What are the dynamics of eating disorders? What conditions will guarantee the survival of the monarch butterfly? What are the effects of different social structures on disease spread?

Once a question that captures the essence of the students project is selected, efforts to build an appropriate model are carried out. These modeling efforts may move us into the world of networks or dynamical systems broadely understood to include stochastic processes or simulations. In the process, the students are assigned a faculty advisor and graduate student support. The incorporation of these individuals is based on the desire of the faculty to get involved in the enterprise and the interest of the graduate student in the project.

The dynamics associated with project, group, question, model, faculty and graduate student selection are driven by the undergraduate students. Consequently, the students are working on problems for which faculty participants do not have the answer. Faculty, graduate students and undergraduate participants become collaborators, and partners in crime.

3.4 Theoretical Philosophy

Confrey (1994, Feb. 1995, June 1995) describes two theoretical perspectives in Mathematics Education: Piaget's radical constructivism – which is, essentially a claim that people's knowledge is an attempt to make sense of their experiences, and Vygotsky's socio-cultural perspective – that people are essentially a collection of privatized social norms. When applied to our own highly cooperative model of MTBI, we find no incompatibility with either.

For example, Vygotsky's work clearly demonstrates the usefulness of establishing a common language among the MTBI participants. This language, in Vygotsky's theory, begins as a social tool – drawing the participants closer together in a cooperative environment, then becomes a conceptual tool – useful

interactions between established and young scientists for working on the problems and research questions that the students are faced with. MTBI devotes three weeks to establishing this common language, which is necessary for the success of the students.

At the same time, the students are doing more than just learning a common language. They are also learning from the interactions with each other by the process of making sense of their environment. From a radical constructivist perspective, interacting with the various students in a cooperative environment that is focused on mathematics provides them with the opportunity to make sense of the behaviors of the other students. The students are more likely to find their models of how mathematics works challenged and developed in this social environment.

However, despite the lack of incompatibly between these two perspectives. We find that their use is primarily in explaining *why* MTBI works, rather than in making recommendations about *how* MTBI *should* work. In terms of deciding how MTBI should work, the viewpoint of Confrey herself (Feb. 1995, June 1995) seems to be more applicable. Which is that limiting oneself to a single model of knowledge or learning is limiting. Synthesis of different viewpoints, such as Confrey's synthesis of radical constructivism, socio-culturalism, and feminism, is a more useful process for developing programs such as MTBI.

Put differently, what works is what works in practice. A theory may be useful in explaining why some aspect of a program such as MTBI works, but some other theory may be better at explaining something else. Various theoretical perspectives have differential explanatory power for portions of an educational program.

It is this concept of diversification of viewpoints that lies at the heart of MTBI's push for increased minority representation in science.

3.5 Meeting Expectations

The following next three weeks are driven by the intensity of the participants to provide an answer to a relevant question. Regular open meetings are conducted were each group presents and defends their effort. On some occasions, students have had to make dramatic changes to their models. Most of the students experience some progress which is not surprising whenever their model or models fit the question posed by the undergraduate participants.

After three weeks a series of results (numerical, analytical and statistical) that throw some light into the question of interest are completed. Students then work hard on writing a technical report ($25 - 45$ pages) that captures the problem, the model, the methods, and their results.

3.6 The product

The participants conclude their efforts with a technical report (111 in eleven years), prepare a 30 minute presentation and highlight their research in a poster. This year, the program began on June 6 of 2006 and concluded on July 29. Seven groups of participants made oral presentations of their results at the join meeting of the Society for Industrial and Applied Mathematics (Life Sciences Group) and the Society for Mathematical Biology which was held in Raleigh North Carolina from July 30 to August 4, 2006. Seven posters were also presented. These posters will be presented at the annual SACNAS meeting in Tampa, Florida (27 of October, 2006) and at the annual AMS meeting in January of 2007. An average of 3 awards per year have been given to MTBI projects. Students regularly have presented their research at their universities and at local conferences during the academic year that follows the completion of the project.

3.7 Relevant Subtle Issues

Creating a community of scholars has to be done with extreme care. For example, minority students at various universities are being awarded fellowships provided by the Alfred T Sloan Foundation. It is known that often students with fellowships tend to do less well than those without them[17] because students with fellowships are often not integrated to the appropriate scientific communities. It is not uncommon in universities where space is a highly contentious issue to provide a desk, a place in the community, exclusively to students who have a paid job to do[18]. The absence of a space in a university setting naturally isolates minority students and prevents them from learning from and teaching to others. Faculty administrators facing the pressures of finding space for a large number of part-time faculty, TAs and RAs (funded by faculty grants) place no priority on implementing practices that may increase retention and graduation rates such eliminating those that prevent indirectly funded students from participating on the daily life of a mathematical community. Ehrenberg in his article in this volume, identifies a problem that was unknown to me, namely that graduate students who publish early are more likely to drop out, but also more likely to get a tenure track position. He adds that graduate student publication is a good indicator or early career publication. Here, I can only speculate as to why this may be a problem in the mathematical sciences. In mathematics there is still (albeit is fortunately fading out or at least I hope is fading out) a tradition of not being able to get a real advisor until one has passed the qualifying exams, a process that often takes three to four years[19]. This length of time without having access to research is, for an increasing number of American students, a cause of despair and probably contributes to the drop out rates that we experience among American students. Are those students who publish taken longer to pass their exams? Or are they spending energy on publications that are not part yet of their theses? MTBI alumni who have worked with me have all completed their degrees with a large number of publications but all have been tied in to their own thesis research and all have passed their qualifying exams early because at Cornell University[20] these exams were not emphasized and the graduate field requirements were minimal, that is, the quality of the education of each student was left primarily on the hands of the Ph.D. advisor who would work close with the student's Ph.D. committee to develop a coherent plan that had a high probability of resulting on a solid Ph.D. thesis.

[17] Ted Greenwood, Sloan Program Director, personal communication

[18] Research or Teaching Assistantship

[19] In math according to NSF the average time to a Ph.D. in the mathematical sciences is at least 7 years

[20] My first Ph.D. ASU students will be graduating in May of 2007.

4 Successes

4.1 Creating infrastructure to sustain an increase in diversity

As successful as MTBI has been at increasing diversity in the mathematical sciences, MTBI is still only one program. Unless the changes that MTBI has created become self-sustaining and self-generating the impact will be short-lived. To this end, we believe that creating a large community of minority scholars that is committed to the issues associated with the problems of under-representation in the mathematical sciences is but the only ay. Such a community will provide the environment where minority success and minority recruitment into the sciences is natural – the norm rather than the exception.

4.2 Encouraging the development of the New American University

MTBI/SUMS philosophy adheres to the principles of the *New American University*[21] that is, MTBI is an institute that, like its home institution, ASU[22], wants to be judged by the quality of the research and academic accomplishments of its students and alumni rather than by the academic pedigree or prior access to *selective* educational settings of its participants. Encouraging the development of this perspective is critical to the goals of MTBI because it directly addresses the disadvantages that many underrepresented minority students face.

MTBI wants to be an institute whose alumni, while pursuing their scholarly and scientific interests, "also consider the public good"[23]. MTBI wants to be an institute whose students, alumni, faculty, and staff "transcend the concept of community service to accept responsibility for the economic, social, cultural, and environmental vitality of the communities they serve."[24]

Communities that systematically recruit and support minority students and that are capable of generating new learning communities such as those instigated by the Applied Mathematical Sciences Institute in California will become the norm as long as there are university models that show that *access* and excellence can not only coexist but that in fact reinvigorate each other within the model of the New American University.

The success of MTBI in creating excellence in the context of social responsibility is best illustrated by the work of Erika Camacho and Steve Wirkus who, only a few years after graduation, have begun to give back massively to the the mathematical community. Erika and Steve have set up a model learning community in just two years.

[21] http://www.asu.edu/president/newamericanuniversity/arizona/

[22] Here, we are paraphrasing ASU's mission but in the context of the work that is being carried out at MTBI.

[23] http://www.asu.edu/president/newamericanuniversity/arizona/

[24] http://www.asu.edu/president/newamericanuniversity/arizona/

5 Why haven't we been able to implement systemic change?

MTBI is a model that works. It has documentable successes and is easy to duplicate. So why aren't we seeing a lot more programs like MTBI? The answer, simply put, is that faculty do not have incentives to do so. As a result, undergraduate students are neglected, and minority undergraduate students especially so.

Advancement and funding for faculty do not come from mentoring successes, particularly at the undergraduate level, they come from research successes. So faculty, who are ambitious by definition, want the most successful research program possible. Running a competitive research program requires getting the most "bang for your buck" in terms of publication results offset by cost and time. Time spent training undergraduate students is then useless, especially when there are graduate students (mostly internationals) who are capable of doing the same things without training. This solution of using international graduate students is more cost effective in terms of both time and money. Faculty research programs are beginning to bear a resemblance to sweatshops. Using the cheapest most cost effective labor possible to produce a product (publications). We call this system the *'maquiladora' model*, a model that has brought immense benefits to our society but an unacceptable model if it naturally excludes the participation of a great percentage of the taxpayers who have built and pay for these institutions to participate in the American *dream.* The importance of internationalization in science is clear and MTBI may be the only undergraduate research program that has supported international undergraduate students[25] systematically but we would not do this to the exclusion of most American students as it is done particularly at the *elite* institutions of this country in the mathematical sciences. We should not be in the business of supporting a society where our underrepresented minority students are not part of the world's largest and most productive scientific and educational enterprise.

The negative consequences of the current system for American undergraduate are high because they are being neglected by faculty who spend *most if not all* of their time managing their research operation (maquiladora). In a well documented article by Zhang in this volume, he notes that the the share of non-resident aliens enrolled in graduate programs in the United States rose from 5.5 percent in 1976 to 12.4 percent in 1999. Furthermore, his article also documents an even more pronounced increase in science and engineering (SE) fields where In the $1999 - 2000$ academic year, non-resident aliens received 38.2 percent ofdoctorates awarded in the physical sciences, 52.1 percent of doctorates in engineering, 26.6 percent in thelife sciences, and 22.8 percent in the social sciences. Finally, Zhang notes that recent data show that in 2002 about 26 percent of alldoctorates awarded in American universities wentto temporary residents, and in SE fields more than 32percent of doctorates were conferred on temporary residents[26]. A social divide has developed between undergradu-

[25] 33 out of 277

[26] In this article by Zhang no data is provided on these percentages relatively to prestige (*elite versus non-elite*) of the universities. In the mathematical sciences the differences used to be pronounced with US students holding a limited number of places at elite institutions a situation that has not further deteriorated due to the establishment of IGER, AGEP and VIGRE NSF programs. Where would we be without programs like IGERT or VIGRE that

ates, graduates, and faculty. As a result, undergraduates in America are not receiving the training they need to compete for these graduate positions. The system becomes self-perpetuating: Fewer Americans are selected because there are better trained international students. There are better trained international students because Americans are neglected.

However, this system cannot continue forever. The problem with using pre-trained international students has multiple dimensions. It appears that less and less international students will stay in the United States. What if we experience drastic reductions on the rates of no-return to their countries of origin?[27] Shouldn't we encourage their return to the countries that educated them? Who will the training of American students be exclusively in the hands of immigrants? Eventually, the overall quality of education that one can receive in China or India will exceed the quality of education that one can receive in the United States. International students won't need us anymore. It is a classic *brain drain scenario.* The issue of role models is fundamental as well, what messages do American students get? That to be a good researcher or a mathematician you have to be born, raised and educated elsewhere!

For minority students, who are already disadvantaged, all the difficulties that American undergraduates are having are magnified. Faculty who already don't have time to train undergraduates are not going to take extra effort to find, recruit and train minority students.

6 Support

MTBI/SUMS efforts have not been carried alone. MTBI received extraordinary support by the Cornell University's administration[28], the Center for Applied Mathematics and the Biological Statistics and Computational Biology Department. MTBI/SUMS has had no less support at ASU[29]. We have established a highly effective partnership with ASU's Hispanic Research Center[30]. ASU's Mathematics and Statistics Department has not only embraced our efforts but has actively joined them. MTBI/SUMS successes have been possibly because of the leadership and hard work of all our partners, supporters, its staff and its summer faculty. However, at the end of the day it is the continuous funding by NSA, NSF and the Sloan Foundation[31] that have kept this effort alive long enough to make a difference.

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only fund US permanent residents or US citizens?

[27]see the article by Oliva in this volume

[28]Malden Nesheim, Don Randel, Biddy Martin, Frank Rhodes, David Call, Hunter R Rawlings III and W. Kent Fuchs.

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[30]Albert McHenry, Gary Keller, Antonio García and Michael Sullivan are the kind of university citizens that every university dreams to have.

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