Influence of NSF Funded Undergraduate Research Assistantships on Underrepresented Minority Students

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Francisco Vigil is from Española, NM. He graduated from NMT in December 2013 with a Bachelor of Science in Mechanical Engineering and is planning to pursue a graduate education at the University of New Mexico. Throughout his undergraduate degree, Francisco was the President of the NMT Society of Automotive Engineers Student Chapter. During his time as president, the chapter grew to become one of the largest chapters in the world. He also volunteered at the NM State Science and Engineering Fair and NM State Science Olympiad. Francisco was awarded the NMT Student Appreciation Award (2013), the DOE Summer Visiting Faculty-Student Fellowship at Sandia National Laboratories (2013) and the University of Illinois at Urbana-Champaign Outstanding Scholarship Award (2012).

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Miquela Trujillo is an engineering student from Española, NM, where she graduated from McCurdy High School. She recently graduated (May 2013) with highest honors from the New Mexico Institute of Mining and Technology with a Bachelor of Science in Mechanical Engineering. During her senior year, Miquela was awarded the National Society of Professional Engineers - NMT Engineering Student of the Year Award. Along with her academics, Miquela is an active volunteer for the NM State Science and Engineering Fair and the NM State Science Olympiad. Miquela also participates in discussions and presentations that promote science and engineering at elementary schools in the Española area. Miquela is planning to pursue graduate studies at the University of New Mexico.

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Ricardo B. Jacquez is Dean of Engineering and Regents Professor at New Mexico State University. He received BS and MS degrees in civil engineering from New Mexico State University and the Ph.D. from Virginia Tech. Over the past 37 years he has served as a faculty member at the University of Missouri-Rolla and New Mexico State University, at the latter for 32 years. He is currently the project director (PD) for the New Mexico Alliance for Minority Participation program and he has served in the role of PI or PD for the Alliance over the past 20 years.

Influence of NSF Funded Undergraduate Research Assistantships on Underrepresented Minority Students in New Mexico

Abstract

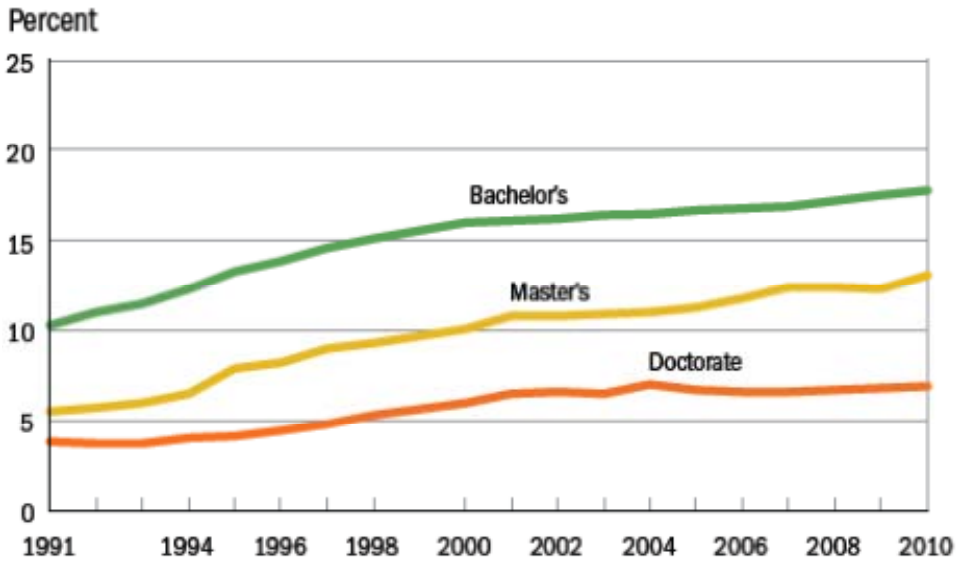
As the nation expects a change in the make-up of its ethnic groups, minorities will increase and play an important role in STEM fields, requiring greater support. In the last twenty years, the State of New Mexico and, particularly, New Mexico State University (NMSU) and the New Mexico Institute of Mining and Technology (NMT) have taken major strides to increase the enrollment of minority students. As a result of these efforts to achieve the status of being Hispanic Serving Institutions, changes were made to the curriculum that would teach underserved students the skills necessary to be successful in a STEM field. Programs, such as the New Mexico Alliance for Minority Participation (AMP), were brought to higher education institutions – including NMSU and NMT – to encourage collaboration between minority students and faculty on research projects, in an effort to promote the pursuit of a graduate education. The New Mexico AMP program was initiated at NMSU, intending to tie the higher education institutions together and supporting students at each of them. This paper will discuss the history of the New Mexico AMP program in detail, discuss student experiences, and provide statistical data on outcomes. This post-secondary STEM program's goal is to recruit students early in their undergraduate careers and integrate them into a working research lab. Engaging minority students in STEM research early in their academic careers proves to be an effective method for retaining interest in such fields and preparing them better for their future careers. Three case studies from Mechanical Engineering students at NMT are included which express the impact of AMP on their undergraduate studies and college careers.

Introduction

As the concept of a global economy becomes more real, the importance of science and technology is more apparent. Thus, nations must be more aware of their competitive position in these fields. Such awareness is extremely imperative, given that science and technology are rapidly evolving as the Internet and other digital communications are making the world appear more intangible. In such a situation, one cannot think of jobs as being strictly limited to a certain locale.

According the U.S. Census Bureau, there is going to be a great change in the make-up of the nation's population. Based on current projections in terms of underrepresented minorities, the United States will be a majority-minority nation by 2043. By 2060, the Hispanic population will be doubled and the African-American population will have increased by a factor of 1.5, along with increases in the other minority groups [1].

Taking these predictions into account, there is currently a strong disparity between the expected number of minorities involved in science, technology, engineering and mathematics (STEM) and what is actually seen. Based on data obtained from the National Science Foundation (NSF) [2], if one looks at the 20-year trend of science and engineering degrees earned by underrepresented minorities, as seen in Figure 1, one can see that there have been minimal increases in these percentages, chiefly in doctoral and master's levels.

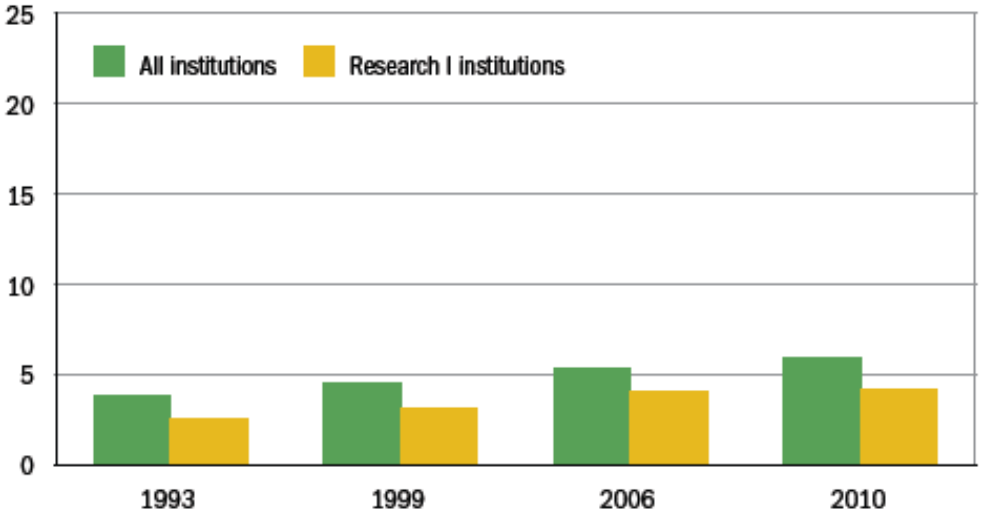


NOTE: Data not available for 1999.
SOURCE: *Women, Minorities, and Persons with Disabilities in Science and Engineering:* www.nsf.gov/statistics/wmpd/.

Figure 1. Science and engineering degrees earned by underrepresented minorities:1991-2010 [2]

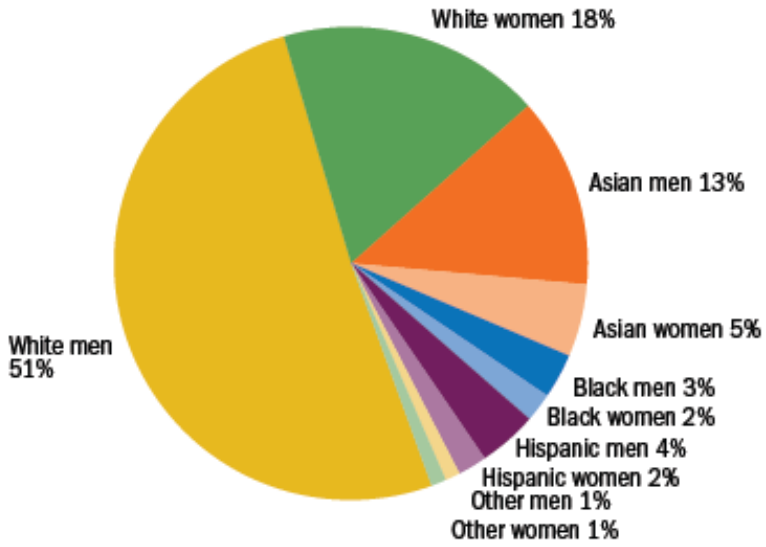
Additionally, as seen in Figure 2, tracking of the percentage of full professors over the same time period shows consistency with regard to the percentage increase of minorities having received doctoral degrees for the last 20 years. Such a small increase presents an issue that those in STEM fields need to address.

There are many significant considerations with regard as to why minorities must be better represented and involved in STEM fields, the prime considerations being diversity and the economy. As the U.S. becomes a majority-minority nation, minority groups will desire to see persons of their own ethnicity involved in STEM fields, including medicine [3]. As noted in Figure 3, minority groups are currently represented by a small percentage of individuals of the same ethnic groups in STEM occupations. Additionally, one of science's primary foundations is diversity of thought and, hence, a diversity of people from various backgrounds and ethnicities. However, with the current lack of minorities in STEM fields, not only will these ambitions not be accomplished, but the nation may also face economic problems. As the nation encounters a lack of qualified scientists and researchers, it will be forced to outsource such jobs from rapidly growing economies, similar to those of China and India. This situation only perpetuates a cycle where minorities continue to be underrepresented in STEM as the U.S. continues to plummet to the bottom of international rankings in math and science, as evidenced by the U.S. ranking 26th out of 34 Organization for Economic Co-Operation and Development (OECD) countries in mathematics based on the 2012 data of PISA [4].



SOURCE: *Women, Minorities, and Persons with Disabilities in Science and Engineering:* www.nsf.gov/statistics/wmpd/.

Figure 2. Underrepresented minorities as a percentage of full-time, full professors with science, engineering, and health doctorates, by institution of employment: 1993-2010 [2]

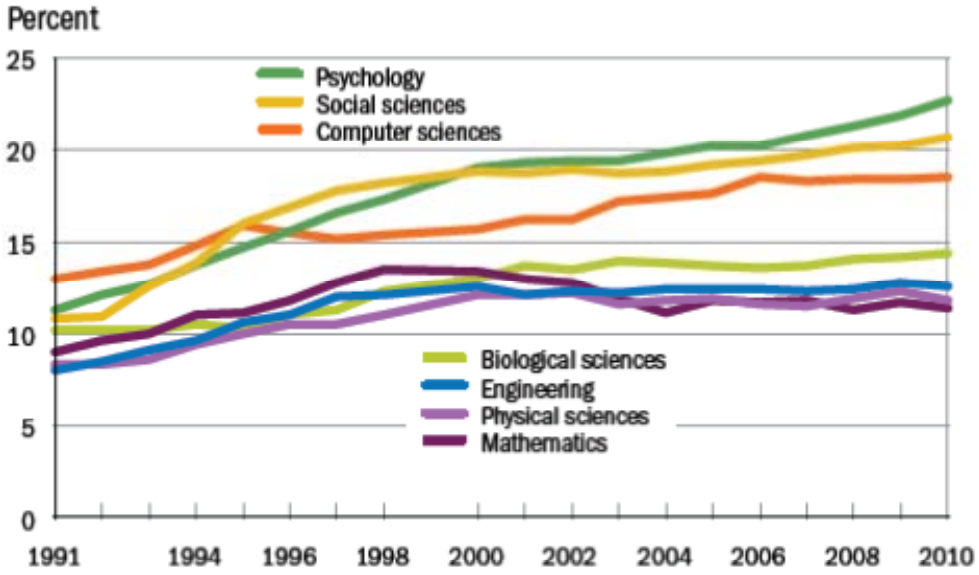


NOTE: Hispanic may be any race. Other includes American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, and multiple race.

SOURCE: *Women, Minorities, and Persons with Disabilities in Science and Engineering:* www.nsf.gov/statistics/wmpd/.

Figure 3. Scientists and engineers working in science and engineering occupations: 2010 [2]

One of the most promising ways in which this discrepancy can begin to be addressed is through better education and support of minorities, tremendously early on in one's career. As seen in Figure 4, a majority of undergraduate minority students do not pursue math and science degrees. Encouraging more minority students to pursue such majors may hold the key to increasing overall minority involvement in STEM fields. Such encouragement would likely include specific programs to support those minority students who do pursue a STEM major to better ensure that they complete their degrees; thus, adding to the competitiveness of the country, as a whole, on the global stage.



NOTE: Data not available for 1999.
SOURCE: *Women, Minorities, and Persons with Disabilities in Science and Engineering:* www.nsf.gov/statistics/wmpd/.

Figure 4. Science and engineering degrees earned by underrepresented minorities: 1991-2010

Given that New Mexico's population is largely composed of underrepresented minority groups, it poses a perfect environment for examining the theory that programs such as New Mexico AMP are successful at increasing the number of minorities in STEM fields. Two of the best examples are Northern New Mexico College (NNMC) which has a 90 percent minority student population and New Mexico State University (NMSU) that is the nation's only land-grant university that is also a Hispanic-serving and research-intensive higher education institution.

Over the last 20 years, and with recent notable success, various institutions in the State of New Mexico have incorporated a support program called the New Mexico Alliance for Minority Participation (New Mexico AMP). In this work, a history of the New Mexico AMP program is detailed along with case studies of the program's impact on 3 undergraduate students who have received great educational and research benefits through the AMP program such as opportunities to present and publish their research.

History of the New Mexico Alliance for Minority Participation

Since its establishment in 1993, New Mexico AMP has impacted the lives of students in New Mexico, their retention in STEM degree programs, as well as, their professional development and progression to graduate school and the STEM workforce. These outcomes reflect the goal of New Mexico AMP to increase the number of B.S. degrees awarded to minorities traditionally underrepresented in STEM. Since New Mexico AMP's launch, the number of STEM degrees awarded to minority students has more than doubled, from 253 in 1992/93 to 586 degrees in 2011, with a total of 7,871 STEM degrees awarded over the life of the program. The Alliance is funded through the National Science Foundation (NSF) Louis Stokes Alliance for Minority Participation (LSAMP) program (1993-2018) and the New Mexico Legislature through a Research and Public Service Project (1996-present).

A Statewide Partnership in New Mexico

The New Mexico AMP is a partnership representing the State's 20 public two-year institutions, including two federally funded institutions serving American Indian students, and the seven state-supported four-year universities. New Mexico AMP is aligned with other federal -funded programs in New Mexico who share a common vision, such as the College Assistance Migrant Program (CAMP), Scholarships in STEM (S-STEM), and the STEM Talent Expansion Program (STEP). Collectively, these and other programs have resulted in a statewide network that has become part of the fabric of higher education in the state, allowing for the managing and leveraging of human and monetary resources, and for quick and accurate dissemination of information and opportunities. These combined efforts help ensure that participating community college and undergraduate students are well prepared in STEM and provided with the encouragement, incentive, and motivation to progress through their educational programs. Program activities are designed to focus on individual student retention and progression, as well as, to understand the aggregation of student progression and to promote the replication of good practices, both within New Mexico and nationwide through professional research conference presentations and other professional development events and publications.

New Mexico AMP Programs

Directly impacting retention in STEM, the Undergraduate Research Assistantships (URA) program, available on several campuses statewide, supports students in faculty-mentored research projects and provides training for research presentation and preparation for internships, graduate school, and/or the workforce. The program also provides oral and poster presentation symposium experience that encourages attendance and presentations at national conferences, including the New Mexico AMP Student Research Conference, which convenes each fall.

The Summer Community College Opportunity for Research Experience (SCCORE) program, started in 2001, provides an annual summer bridge program for statewide community college students. The goal of SCCORE is to develop the talent of community college students by providing opportunities to conduct research with university STEM faculty and to heighten students' awareness about campus resources and university life. The program provides research opportunities, fosters student success, and assists students in the transition to New Mexico AMP

baccalaureate-granting institutions. Students outside the local area reside on campus, and all students attend a credit-bearing course and receive professional development training.

Since 1996, the Student Research Conference brings students and faculty together from New Mexico's colleges and universities, as well as, students and teachers from the New Mexico Math, Engineering, Science Achievement Inc. program (New Mexico MESA). The conference provides an annual opportunity for students to present research, gain presentation experience, network with other students and faculty, and participate in workshops and panels. These opportunities directly impact student retention in STEM and focus on student and faculty professional development. The conference offers the Community College Professional Development Seminars for students from New Mexico AMP's two-year partner campuses. These students are provided an understanding of the goals and purposes of the conference and assistance with navigation of the conference events and opportunities.

The New Mexico AMP Transfer Scholarship is also available to community college students transferring from a two-year to a four-year institution to pursue a STEM degree. Available as students begin their first semester at a four-year institution, the scholarship provides imperative financial assistance during this crucial time of transition.

Impact on AMP Students at NMT

One of the most tangible benefits of New Mexico AMP to students is the monetary award that accompanies the URA every semester. The monetary award allows students who would otherwise have had to find outside employment to support their education, to spend their time conducting research that is related to their field of interest without a financial burden. Oftentimes professors have a limited number of paid research positions available, if any. This decreases the likelihood that minority students will gain paid research experience at the undergraduate level. The included case studies reinforce this sentiment.

Most often, the only hands-on experience that undergraduate students receive in their coursework is from their limited number of engineering laboratory courses. Students in the case study felt that they learned the fundamental concepts of their courses more thoroughly through their research experiences and solving problems. This additional problem based learning served as a unique learning aid in areas of their engineering discipline. Problems encountered in the laboratory helped students learn the difficulties of designing and conducting physical experiments that they would not otherwise be exposed to. Oftentimes, diagnostic methods that are new to the student would have to be learned and their experiment designs would have to undergo a period of trial and error. All these skills and experiences improve the student's engineering ability and therefore make them better candidates for graduate school or the workforce.

Especially at large institutions students often complain about the impersonal relationships with professors. Because of this students frequently label themselves as simply a "number among many." The students who have participated in AMP reported that they built professional relationships with the professors they work with. These professional relationships benefit the students in multiple ways, such as building a strong reference for job or graduate school applications. Oftentimes these connections lead to an introduction to academia, including the publication process, presenting at conferences, and grant/proposal writing. Students are exposed to one-on-one instruction on research fundamentals and scientific concepts related to their

research provided by their professor. In the case study, students reported that the career advice from their professors and the New Mexico AMP cohort proved invaluable and unique.

New Mexico AMP has greatly benefited the careers of the participating NMT students by allowing them to experience research in various fields of engineering where they gained valuable skills that have made them attractive in the workforce and in academia. The structure of the program gives students a taste of life as a graduate student and helps them decide if they would like to pursue graduate education or a career in research. This outreach has been successful at NMT. Out of the five AMP students who have graduated with a BS since 2012, three have started graduate programs with the intent to pursue a Ph.D. in a variety of engineering disciplines.

Case Studies

The following are three case studies of individuals who were positively impacted by the New Mexico AMP program. All three students received URAs at NMT. Students participated in a research process as a team, from the design of experiments to the presentation of their results. Upon completion of the experiments, students presented their work in peer-reviewed journals and as oral presentations. Involvement in this research helped students in their coursework and provided them with skills that will prepare them for a graduate education. Each case study includes background information on the student and the impact the program has had on them, including direct thoughts and quotes from these students concerning such.

Student 1

The first student was supported by the AMP program during three years of his undergraduate studies starting the sophomore year of his college career. He graduated from McCurdy High School in Española, New Mexico. Like many schools in the region, he stated that McCurdy had a weak science program, which left him ill prepared for the challenges that he faced in college. This individual participated in activities, such as the State Science Fair and New Mexico MESA while in high school. He stated that his involvement in the State Science Fair was where he was first exposed to the intricacies of conducting one's own research. These experiences made him an attractive candidate to professors for a research assistantship funded by New Mexico AMP. In his sophomore year he began working in the Fuels and Combustion Science Laboratory at NMT where he conducted experiments to investigate the performance of various bio-fuels in compression ignition (CI) engines. Much of this work was presented at the annual AMP Research Symposium and published in peer-reviewed journals. Participation in AMP led to other research opportunities at the University of Illinois at Urbana-Champaign and Sandia National Laboratories.

The individual's participation in AMP contributed greatly to his education and professional development. Although AMP focuses on providing research opportunities for minority students, in an effort to encourage the pursuit of graduate studies, he also felt that AMP helped him in his coursework as well. His research required an understanding of chemistry and thermodynamics in order to properly conduct experiments. Oftentimes, content taught in his coursework would parallel what he was doing in the laboratory. He stated that having prior exposure or overlap with content in his coursework helped him gain a deeper understanding of the material being taught.

In his own words, the greatest positive impact of his own experience with AMP was that it "gave me the opportunity to find my likes and dislikes within the broad field of Mechanical Engineering." The student felt that his AMP advisor took great interest in helping him find his passion and exposed him to computational fluid dynamics (CFD), various types of combustion, and experimental mechanics of materials. Finding his niche helped him excel at his research and eventually earned him a position as a research assistant in the Combustion Physics Laboratory at the University of Illinois at Urbana-Champaign for one summer. He feels that his interaction with his AMP advisor and the opportunities that AMP provided formed his passion for research and shaped his career goals. His involvement with AMP not only exposed him to research in a laboratory, but also gave him a glimpse into the world of academia and showed him what a career in research involves. Had it not been for his AMP research advisor, he would not have been exposed to the process of publishing scientific papers in peer-reviewed journals until graduate school.

These experiences aided him in forming his interests, all while presenting him with a taste of the graduate student experience. He spent long hours in the laboratory conducting experiments. There, he often encountered issues, which were solved by conferring with other undergraduate research assistants. This allowed him to experience being a part of a research group.

His desire to pursue a PhD and work in a research setting were accredited to the experiences he had as part of the AMP program. He explained that it is difficult for students who are young in their academic careers to interact with faculty members, much less form professional relationships. Although AMP focuses on research in a university setting, he feels that undergraduate research was the central piece that presented him with a number of other opportunities. The individual participated in STEM programs throughout his secondary education and during his undergraduate education; however, he stated that AMP was the most successful and influential program he has experienced in fostering the search for graduate education for under-represented minorities. He felt that the combination of a motivated research advisor and the resources that AMP provides could help minority students overcome the many educational hurdles that they frequently encounter when they enter their undergraduate program.

Student 2

The second student was supported by the AMP program during her junior and senior years of undergraduate study. She first became aware of the AMP program when she transferred to New Mexico Institute of Mining and Technology during her sophomore year. This program attracted her attention because she had a desire to conduct research and pursue a post-bachelor degree in engineering. The New Mexico AMP program allowed her to contact several professors in the Mechanical Engineering Department and conduct research that interested her. One of the prime benefits of this program is that it allows minority students – who would otherwise have a challenging time obtaining a research position in professors' lab – an opportunity to become involved and conduct research, free-of-charge. As a result, she worked with multiple professors and graduate students on several projects that led to other opportunities in her future college career.

She began her undergraduate research profession in Materials, and since she was funded through New Mexico AMP, she presented her findings at the 2011 AMP Student Research Conference where she received second place for her oral presentation. Other opportunities arose

from her research. In 2011, she was also awarded the New Mexico Space Grant Consortium Scholarship.

As her participation in the New Mexico AMP continued, she had the opportunity to conduct research with another AMP student on diesel engine emission testing and on a collaborative aluminum combustion project with Sandia National Laboratories. They performed a series of tests to investigate the impingement of molten aluminum particles on a dry wall at various temperatures and impingement angles. The results from these tests were used to improve and verify a computational model. They also conducted a series of tests to determine the effects of different concentrations of ethanol, bio-diesel, and diesel on emission characteristics. The outcomes of these experiments were presented at the New Mexico Alliance of Minority Participation 2012 Student Research Conference where she was, again, awarded second place for her oral presentation.

The New Mexico AMP program has had a positive impact on her academic and professional occupation as an engineer. This program allowed her to gain research experience in areas that she would have otherwise not been able to obtain. As she concluded her undergraduate degree and began applying to graduate research programs, she realized how valuable the opportunities New Mexico AMP provided were to her future successes. Research in the academic environment is one of the most sought after skills for incoming graduate students. Many students fail to conduct research at the undergraduate level because of the limited availability of funds. However, since New Mexico AMP provides funding for these students, she was able to conduct investigation on a project and with a professor of her choice. She learned essential critical thinking, research, and hands-on skills that are necessary for graduate students. Because of her research experience at New Mexico Institute of Mining and Technology she was accepted into a summer research program at the University of Michigan, where she worked in the Smart Materials and Structures Research Laboratory. The experiences she gained from that program also aided in her achievements as an intern student at the Los Alamos National Laboratory. As intended, the New Mexico AMP program provided her with the necessary skills and experiences needed to conduct research at a graduate level. As a result, she was accepted into multiple graduate programs around the country.

Student 3

The third student has been supported by the AMP program since August of 2013. She began research during her sophomore year of college. Studying different fuel combinations and CI engine emissions has been very informative for her. She now has a better grasp on Mechanical Engineering. The different tasks and difficulties of research are more apparent, including how important details and consistency are. Research has advanced her ahead of her peers and she deeply enjoyed discovering notions concerning the fuel combinations and working with the different engines. “Working with the jet engine was actually very entertaining and exciting,” she proclaimed. Presenting the material in a conference gave her a greater understanding of the research, which was taking place. She understood why the other research assistants were doing what they were doing and the potential of the research, as she learned of the more efficient ways to power engines. The research has also helped her uphold a better grasp on the chemistry involved in Mechanical Engineering. The student has grown better prepared for future classes such as engineering fluid mechanics and thermodynamics. She is prepared to utilize the different chemicals and fluids needed in those classes, as well as, have a better understanding of the heat

and energy required for work. Her primary reason for choosing Mechanical Engineering was to use it as a "foot in the door" to Aerospace Engineering, but she now has a greater interest in Mechanical Engineering. The research was enormously interesting, and she was thrilled at her ease of understanding the work being done. Aerospace continues to be her primary goal, yet she is also intrigued about the fields of Mechanical Engineering. There is not a multitude of enormous hardships concerning being a Hispanic in New Mexico, but it continues to be difficult to obtain equal treatment between employers and being taken seriously with a Hispanic name. The New Mexico AMP program continues to be of great importance in her life. The research has helped her increase her knowledge, while the scholarship has assisted in maintaining her enrollment at New Mexico Institute of Mining and Technology. This program is promoting and expanding the participation of minorities to excel. Today, New Mexico AMP is promoting her pursuit of engineering and allowing her the opportunity for a better future.

Outcome of New Mexico AMP

The New Mexico AMP program has proven to be successful at involving minority students in research and increasing the number of minority students pursuing STEM degrees. Although the three case studies are from Mechanical Engineering students at NMT, the New Mexico AMP has had a similar positive impact on participating students from other institutions. Over one hundred students have participated in NM AMP. Out of those students, forty percent of those who have already graduated with a B.S. in a STEM field have continued on to graduate school. Of that forty percent, twenty five percent are pursuing a Ph.D. in their respective STEM fields. With the help of the NSF and the New Mexico Legislature, New Mexico AMP continues to fund minority students in STEM fields throughout the State. The above case studies provide an intimate view of the benefits of New Mexico AMP to individual students but the overall program's statistics prove its effectiveness.

Conclusions

The New Mexico AMP program demonstrates that active support of minority students in STEM fields enables them to chase such fields in their academic careers. Through activities including sponsored conferences, symposiums, and presentations, students are able to gain real-world experience, which will serve them presently, as well as later on in life; thus, minority students are given the opportunity to become contributing members in the workforce. Case studies indicate that such advantages have a more dramatic effect when students are involved in the AMP program early on in their academic studies. Their interest and motivation to pursue graduate studies are increased, aided by experience, encouragement, and confidence to pursue research opportunities away from their home institutions. This allows for a dissemination of minority knowledge which increases diversity and cultural enrichment at these institutions. When students are involved in STEM as early as possible, success of any similar program is easily found. By increasing the number of qualified minorities in STEM research and occupations, the U.S. can be certain to remain on-track with the ever-evolving ethnic make-up of the country, while increasing its competitiveness with other world powers.

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