A Decade of Lessons Learned

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ABSTRACT

We describe our efforts at building programs in Earth and space science over the past decade at four Minority Institutions, Medgar Evers College, Norfolk State University, South Carolina State University and the University of Houston-Downtown. We present our institutional models of success and programmatic outcomes as well as barriers to success and lessons learned. The unique path to success for each school is described, along with experiences common among all four. Since these institutions do not offer graduate programs in the geosciences, they have concentrated on recruitment and retention of students in the K-16 pipeline while preparing them for graduate school and careers in the field. These schools represent a range in size, location, population served and in the type and nature of the Earth and space science programs they offer. As such, the experiences described herein offer a broad perspective on what does and does not work in attracting and retaining underrepresented minority students in the geosciences.

BACKGROUND

A number of recent articles have highlighted successful programs at Minority Institutions (MIs) that have led to increased participation in science and engineering fields by students and faculty at these institutions. An article by Sakimoto and Rosendahl (2005) discusses a NASA program that has enhanced involvement in space science at nearly two dozen MIs around the country. The work of Stassun (2005) describes a collaborative program between Fisk University and Vanderbilt University that has impacted the K-16 pipeline and serves as a bridge to graduate school for underrepresented minority students in astronomy and related fields. In the publication by Summers and Hrabowski (2006), the authors discuss the Meyerhoff program at the University of Maryland, Baltimore County, and its impact on minority undergraduate and graduate student recruitment and retention in the science, mathematics, engineering and technology (STEM) fields. These three articles and references therein provide a good overview of the paucity of minority representation in the STEM pipeline and offer some successful strategies to overcome this problem.

We describe herein our own experiences over the past ten years as they relate to the geosciences. Our four institutions, Medgar Evers College (MEC), Norfolk State University (NSU), South Carolina State University (SCSU) and the University of Houston-Downtown (UHD), have been engaged in a variety of Earth and space science programs in research, education and outreach. Based on a decade of experience at each institution, we present our models of success, programmatic outcomes, barriers to success and lessons learned that may be of interest to others. As summarized in Table 1, we represent a cross section of rural and urban institutions, midsize and small schools, Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs) and Other Minority Universities (OMUs).

We are motivated to submit our experiences as a group based on long standing collaborations among our institutions. Some of these activities go back to 1995 as part of NASA's Minority University SPace Interdisciplinary Network (MUSPIN). Additionally, we have partnered through other NASA Minority University Research and Education Programs (MUREP) such as the Partnership Award for the Integration of Research (PAIR). More recently, the four institutions have worked together as recipients of the NASA Minority University and College Education and Research Partnership Initiative (MUCERPI) awards in 2000 and 2003. The schools have exchanged student research interns, hosted workshops together, supported each other's grant proposals and are currently working together on joint projects in both Earth and space science.

MODELS OF SUCCESS

The models of success for each institution are described below. While each school has followed its own path to success in developing programs in Earth and space science, elements common to the four institutions are also apparent.

The UHD Model (HSI) - UHD STEM programs primarily focus on preparing students for careers in industry, public school teaching and entry into professional and graduate school. Relevant degree offerings at the undergraduate level include biology, chemistry, computer science, engineering technology and mathematics. A new B.S. degree in geosciences will be offered beginning in 2009, a contributing outcome of the NASA MUCERPI program at UHD. Currently there are no STEM graduate degrees offered, but a master's program in natural science is presently being evaluated.

UHD significantly increased its involvement in Earth and space science (Morris et al. 2005) beginning in 1997 when a geology faculty member received a summer fellowship appointment at the Johnson Space Center (JSC). UHD then received NASA MUCERPI awards in 2000 and 2003. This same faculty member redirected her

	MEC	NSU	SCSU	UHD
City	Brooklyn	Norfolk	Orangeburg	Houston
State	NY	VA	SC	TX
Locale	Urban	Urban	Rural	Urban
MI Type	OMU	HBCU	HBCU	HSI
Funding Type	Public	Public	Public	Public
Total Enrollment	5,300	6,000	4,200	11,000
Undergraduate Enrollment	5,300	5,700	3,700	10,400
Female Enrollment	76%	69%	60%	59%
African American Enrollment	91%	86%	96%	31%
Hispanic Enrollment	4%	2%	< 1%	39%

Table 1. Institutional profiles.

research to focus on extraterrestrial geological materials and, as a result, a strong partnership developed between UHD and the Astromaterials Research and Exploration Science Laboratory at JSC. Other UHD faculty and students are now involved in education, outreach, and research partnerships in and around Houston that include Texas Southern University (HBCU), Rice University, the Houston Museum of Natural Science, NASA Johnson Space Center (NASA JSC) and the University of Texas at Brownsville (HIS) (Morris and Obot, 2005 and 2006). UHD has further expanded its collaborations to include national partners.

UHD has used the MUCERPI awards to create an interest in the geosciences which has resulted in an increased enrollment and the hiring of a new tenure-track geology position, add a new course in astrobiology and develop the previously mentioned B.S. degree in geoscience. A number of teacher workshops are offered each year within the greater Houston and Brownsville environs. Additionally, the UHD program has included extensive outreach to the community through its Space Science Student Ambassador program.

The SCSU Model (HBCU) - SCSU offers undergraduate degrees in biology, chemistry, computer science engineering technology, mathematics, nuclear engineering and physics. The physics program offers an option in astronomy and a minor in astronomy for physics majors and non-majors respectively. No graduate programs relevant to the geosciences are offered. Consequently, STEM activities have focused on undergraduate students including preparation for graduate school.

SCSU has implemented a comprehensive K-16 program in space science covering research, education and outreach. During the past decade, astronomy has been institutionalized at SCSU as described in the works by Sakimoto and Rosendahl (2005), Walter et al. (2005), Walter and Payne (2006), and briefly summarized here. In 1994, SCSU was nominally involved in astronomy. The campus planetarium presented public and school programs, it was a member of the South Carolina Space Grant consortium and it hosted the NASA Educator Resource Center (ERC) for the State of South Carolina. While several physics faculty members had an interest in the field, there were no astronomers on campus until a recent Ph.D. in the field was hired in 1994. By 2006, there were a total of ten faculty members engaged in some type of space science activities, including three astronomers. The University partners with national labs, NASA centers, MIs and majority institutions around the country. It has part ownership in the 1.3 meter telescope at Kitt Peak National Observatory, conducts teacher workshops in astronomy and astrobiology, offers an astronomy minor and engages in faculty and undergraduate student research. Two high schools in South Carolina have added astronomy courses to their curriculum after taking a NASA-funded space science summer course at SCSU, while nearly 30 other middle and high schools use the SCSU course materials while teaching existing science classes.

The NSU Model (HBCU) - NSU offers STEM undergraduate degrees in biology, chemistry, computer science, engineering, mathematics, physics, naval science and technology. A Master of Science is offered in each of the fields of computer science, engineering and material science. As a result of support provided under the NASA MUCERPI program, a minor is astronomy was introduced in 2003.

NSU has dramatically increased its involvement in space science over the past ten years through awards from NASA and the National Science Foundation (NSF) and in-kind support from the Department of Energy's (DOE) Jefferson Laboratory through the use of its facilities. The campus planetarium has been extensively refurbished with University funding and is now heavily used as a classroom for undergraduates as well as for teacher workshops and public programs. A research observatory is being constructed at a dark site off campus with funding from NSF and NASA. The planning and building of this facility has been a catalyst to developing a mutually beneficial working relationship between NSU and the local Back Bay Amateur Astronomers. The observatory and potential research it will support has also helped grow partnerships with the University of Virginia and other majority and minority institutions around the country.

Existing faculty research experience in particle detectors has led to a partnership with NASA scientists at the Goddard Space Flight Center. In less than three years, a new minor in astronomy has grown to a current enrollment of four. New astronomy courses assisted two other underrepresented minority students to acquire the background needed for admission to graduate programs in astronomy, one going to the Fisk/Vanderbilt program and the other to the University of New Mexico. An annual summer workshop on "Topics in Modern Astronomy" draws about 50 teachers, amateur astronomers and faculty members. Middle and high schools in the Hampton Roads area have funded their own teacher enrichment program with programmatic support from NSU astronomers; while the Virginia Beach Public School System began to offer a year long astronomy course at the senior level after a number of the teachers in their district took space science courses from the revitalized program at NSU.

The MEC Model (OMU) - MEC is primarily a teaching institution in the City University of New York (CUNY). Undergraduate degrees offered in STEM areas include environmental science, computer science, math and biology. A CUNY-wide undergraduate degree in space science is offered to MEC students. A number of minors are also available in STEM areas including Earth systems science, chemistry, computational science/remote sensing and physics. MEC does not offer graduate programs, but over fifty percent of its graduates in the computer science and environmental science programs pursue graduate studies. This success rate is due to the major emphasis on the integration of research into the undergraduate curriculum and the interdisciplinary nature of the program.

The Department of Physical, Environmental and Computer Sciences at MEC has been engaged in NASA-funded programs in Earth and space sciences for the past 10 years as described in Austin et al. (2002), Johnson et al. (2004a) and Sakimoto and Rosendahl (2005). This involvement was initially stimulated by participation in the Institute for Climate and Planets (ICP) based at the NASA Goddard Institute for Space Studies (GISS). This program provided support for faculty research associates, undergraduate and high school students as well as high school teachers. The ICP brought together a critical mass of CUNY faculty engaged in related research and educational programs. This, in turn, led to a number of new initiatives involving NASA programs such as MUCERPI, MUSPIN, PAIR and others as well as CUNY-wide collaborations and external partnerships with SCSU, NSU, UHD, Cornell University, the University of Rhode Island and the University of Vermont. These programs have increased significantly the number of undergraduate STEM majors and students in the Earth and space science graduate school pipeline.

Model Summary - An examination of the above four models show both unique experiences and common elements. It may be useful to others to summarize and elaborate on the more important elements that contributed to these successful programs.

One or two faculty members at each institution, so-called "champions of the program", were critical to its initial development and its subsequent growth. In some cases this began with a new-hire fresh out of graduate school (SCSU) or an established faculty member retooling her research (UHD) to match externally-funded programs. At the other institutions, it involved a faculty member single-handily bringing outside collaborations to the school (NSU) or internally facilitating cooperative research among faculty members who previously did not work closely together (MEC). It should be noted that while upper-level administrative support was important, the program champions at these model schools were faculty members at the department level who initiated the development of the geosciences and then provided the leadership necessary to sustain its growth.

Internal and external collaborations were absolutely essential to the success at all four institutions. As with most MIs, none of these model schools had sufficient resources or personnel in the geosciences to grow a program that involved more than one or two faculty members. Each of the four schools developed large networks locally and nationally that allowed them to tap into other people, programs and resources. It was useful and in some cases essential to go beyond the so-called geoscience comfort zone and partner with people in other fields such as engineering, mathematics, computer science and education.

The physical proximity to a nearby research facility was important at most of the schools. The ease of access to other researchers, laboratory equipment and opportunities for student interns provided capabilities from the beginning that allowed the programs at the corresponding MIs to flourish. While NASA and DOE facilities were part of the programs described herein, other schools may find that nearby majority institutions or private industry can provide similar support.

Building on existing strengths in the geosciences at each school was very helpful during the initial growth. This included the use of facilities such as laboratories and planetariums as well as collaborating with established projects, such as the climate-studies group at MEC and the NASA ERC at SCSU. Partnering with existing programs was appealing both to the funding agencies as well as administrators and faculty at the home institutions. Enhancing or expanding on these programs was less expensive than building from scratch and generated internal support from others who are already using them.

Significant institutional support was critical to the success of these projects. In some cases this support included funding, in other cases the creation of new faculty positions or new courses. For each program to achieve maximum success, support was needed at all levels within the institution, from faculty peers to the Chair and Dean to the upper-level administration. Consensus-building was often a long and torturous process. However, when a consensus at each level was not reached, program implementation was delayed or not fully achieved. Frequently the funding agency required such support and to their credit, the agency was often understanding of the limited resources at the MIs. Typically they allowed each school to provide the required support through a means that best fit the school's mission, goals and capabilities.

All four institutions had a strong K-12 outreach program. At first glance it may not be apparent why this was a factor in their success. However, it should be noted that many of the programs that funded the growth of the geosciences at the MIs required education and public outreach (EPO) components. MIs have historically had strong ties to their local communities, so finding strong K-12 partners for their proposals was easier than it might have been for other institutions. This is an important point to be noted by both funding agencies and majority institutions trying to address the underrepresentation of minorities in the science pipeline. MIs make excellent partners in such efforts and most have higher rates of

Program	Level	Period	Years	First Time Students	Returning Students	Total Participants	Graduate School
PAIR	pre-REU	2000-2004	4	47	4	51	45%
URIA I	pre-REU	1998-2005	8	48	12	60	38%
URIA II	REU-like	2001-2005	4	13	5	18	77%

Table 2. SCSU internship programs in astrophysics.

success in graduating minorities and underrepresented groups than research institutions.

SUCCESSFUL PROJECT OUTCOMES

Each institution has implemented a number of successful programs over the years. We present a sampling of those related to the geosciences.

The SCSU Internships in Astrophysics - SCSU has developed a highly successful, two-tier program of undergraduate internships in astrophysics. As a point of comparison to the well known NSF program, Research Experiences for Undergraduates (REU), the SCSU tiers are characterized as "pre-REU" and "REU-like" in nature. Table 2 summarizes the SCSU program.

The SCSU PAIR program was a 12-month internship that included an eight week residential summer component followed by two academic-year semesters of part time research. Interdisciplinary teams of three to five students each worked under the mentorship of a STEM faculty member on a research project. Team projects varied depending on the background of the faculty mentor, but all involved some application to radio astronomy. For example, one team developed a temperature control system for a radio telescope at the Pisgah Astronomical Research Institute in North Carolina while another team developed a web interface to remotely control the radio telescope over the Internet.

The SCSU Undergraduate Research Institute in Astrophysics (URIA) Level I was an eight-week, summer residential program on the campus of SCSU designed to give students interested in space science a pre-REU research experience. Students were recruited nationally and participants were selected from thirteen different MIs. The program included a two week overview of the field of astrophysics followed by a six week team research project. Examples of projects included computer modeling of binary star systems, studying large data sets from the Sloan Digital Sky Survey and analyzing images of galactic emission-line nebulae.

The URIA Level II program placed students with some previous space science research experience (usually PAIR or URIA I) at national labs such as the Kitt Peak National Observatory (KPNO), the NASA Goddard Space Flight Center, the Johns Hopkins Applied Physics Laboratory, the Lawrence Livermore National Laboratory and others. These REU-like experiences included working with scientists at the site on current problems in astrophysics. The results of one such project on solar physics lead to a peer-reviewed publication (Kucera, et al., 2003) that included a URIA II student as a coauthor. Other projects led to student presentations at national or regional meetings such as the work of Duenas and Mighell (2002).

The success of the two-tier approach and the important role played by an undergraduate research experience at an MI is obvious from examining the last column of Table 2. The high percentage of students attending graduate or professional school is actually a lower limit since we have had difficulty tracking some of the students at other institutions. Of particular note is that ten of the thirteen (77%) first time students who participated in the REU-like, URIA II experience then went on to pursue an advanced degree.

The key to success in this type of program is providing students with an initial research experience at an MI, where faculty traditionally provide a nurturing environment for students and interact more closely with them than at most research institutions. After the student has gained the skills and confidence needed while at the MI, they are more likely to succeed elsewhere. The first tier of the program also helps select out the students most likely to succeed in the second tier. Similar results were found at Elizabeth City State University (a HBCU) with a two-tier geoscience research program for undergraduates as described in the work of Hayden, et al. (2004).

Success of the two-tier approach requires close partnering between the MI and the research institutions. It is in the interest of both groups to ensure that the research at the MI is current and relevant. Finally, a successful program requires funding that can support research at both institutions. Programs that simply provide funding to send students to research facilities without investing in the MI portion of the program will not be as successful.

The MEC/CUNY Earth and Space Science Programs - MEC and its CUNY partners have been heavily involved in Earth and space science activities over the past decade. Two of the more successful programs include the Meteorological Network (METNET) and the MEC Sub-orbital Satellite Science and Technology (MECSAT) program.

The METNET program established a data network of meteorological stations at numerous K-12 schools, colleges and universities in New York City that were linked through the Internet. Data collected at these sites were used to understand climatological and meteorological features of the New York City's urban heat island and seabreezes. The METNET program is no longer formally active, but the infrastructure and resources are still in place and is used by individual schools.

METNET, however, was more than a data network. It was a comprehensive program that integrated Earth and space science into the K-16 curriculum (Hope and Johnson, 2000). It included research by NASA scientists, university faculty, graduate and undergraduate students as well as high school teachers and students. Curriculum enhancement in the K-16 community included topics from the fields of astronomy, meteorology and geology among others. Teacher workshops and student internships were an integral part of the program.

MECSAT is a high altitude balloon program managed at MEC with interdisciplinary student-based projects in Earth science, space science and technology (Austin et al. 2004 and 2005, Johnson et al. 2004b). Although MECSAT has been in existence for less than three years, it has been highly successful. MEC students and faculty have launched Ozonesondes and balloons with instrument payloads from sites in Colorado, Montana, Iowa, New York and Vermont. Partnerships have been formed with NOAA, the NASA AURA EPO team, the New York Space Grant Consortium, Montana State University and the Universities of Rhode Island and Vermont. MEC included NSU, SCSU and UHD in their training and launch activities during the summer of 2006.

METNET and MECSAT have had a tremendous impact at MEC and CUNY over the past ten years. Reporting requirements were not standardized across various funding agencies and even among different programs within an agency. Therefore, it is not possible to fully report all impacts in these areas and the ones below are generally the minimum number recorded in each area.

- A least 15 CUNY faculty were directly involved
- Over 200 undergraduates have been or are now involved in geoscience research
- More than 30 graduate students are pursing or have pursued advanced degrees in the geosciences as a result of their undergraduate research in the field
- Over 30 hard-to-staff K-12 minority schools were directly impacted
- Approximately 150 K-12 teachers received training
- More than 3,000 K-12 students were impacted by curriculum integration
- At least four peer-reviewed publications and scores of conference posters and oral presentations have disseminated the results of these two programs

The UHD Space Science Ambassadors Program - The NASA-funded Space Science Student Ambassadors program at UHD is designed to interest high school and college students in space science careers while providing outreach activities to the community. Students are trained to interact with their peers and the public while promoting space science through demonstrations and interactive activities. The Ambassadors are recruited from urban areas, predominantly minority high schools and universities. Each Ambassador team consists of three members, a mix of high school and college students. The students gain expertise in space science topics, strengthen their speaking and organizational skills and learn about potential careers in STEM fields. The success of this aspect of the program is demonstrated by the fact that at least fifteen of the college students from the Ambassador program are now enrolled in graduate or professional school, including two in the graduate geoscience program at Louisiana State University.

The program has grown from approximately twenty to forty annual events or venue sites. The venues vary from one-day events in museums and city parks to those lasting three weeks at schools and neighborhood centers. Activities range from building volcanoes and comets to workshops entitled "Planetary Accretion" and "Edible Rocks", in which different types of candy bars are used to describe rock types. The outreach activities are so popular that UHD cannot fill all requests it receives. The impact of this program on the student Ambassadors and the community they serve is summarized for the six-year period 2001-2006. In the case of the college Ambassadors attending graduate school, the number listed represents a lower limit since it has been very difficult to maintain contact with students after they leave the Ambassador program.

- A total of 25 high school Ambassadors participated
- A 100% success rate was achieved when all 25 of the high school Ambassadors later enrolled in college
- A total of 59 college Ambassadors participated
- At least 25% of the college Ambassadors later enrolled in graduate or professional school
- A total of 27 K-12 schools hosted or attended events
- A total of 78 community events (1-day to muti-week) were offered
- A total of 45,805 people participated in the school and community events above

The NSU EPO Program in Astronomy - NSU refurbished its on-campus planetarium in 2001 and has used the facility as a focal point for its EPO program in astronomy including teacher workshops, undergraduate astronomy courses, public shows and science movie nights. The NSU faculty provided science content to K-12 teachers in the area as they developed middle and high school courses in Earth and space science. Additionally, NSU has developed strong ties to the local Back Bay Amateur Astronomers club. This partnership is of benefit to both groups. The amateurs provide assistance with public observing sessions and in promoting NSU programs. NSU provides scientific content to some of the amateur projects and the two groups are preparing to conduct collaborative research once the NSU observatory is completed. Beginning in 2001, the NSU EPO program in astronomy has accomplished the following:

- Over 6,000 participants have used the NSU planetarium since its refurbishment
- A total of 195 individuals have participated in the summer astronomy workshop
- A total of 105 of the 195 workshop participants have been in-service teachers
- The Virginia Beach Public School System developed a year-long astronomy course at four (4) schools after their teachers attended the NSU summer workshop
- A total of six (6) school systems in the area funded their own teacher enrichment programs with programmatic support from the NSU EPO Program in Astronomy
- Approximately 100 Earth and space science teachers were impacted by the enrichment programs developed in the six school systems

BARRIERS TO SUCCESS

All four institutions have encountered significant barriers over the past decade while developing their Earth and space science programs. Some of these issues are internal to the MIs while others have external sources. The most frequently noted barriers include:

1. A number of examples exist where MIs were named as partners on proposals without contacting the MIs involved. This problem has largely disappeared in recent years as a result of a more rigorous

documentation process required by the funding agencies when proposals are submitted.

2. Some partnerships between MIs and research facilities have been short-lived or failed outright. This is due, in part, to differing expectations by the two parties, expectations that were not fully discussed before agreeing to the partnership.
3. Students sent from MIs to research universities, NASA centers and government laboratories have not always been welcomed or adequately mentored. Great care is necessary in selecting research mentors to ensure that they are genuinely interested in working with the students.
4. A low level of involvement by MI faculty in NASA missions and other high profile projects leads to a low level of student involvement in these projects and less competitive candidates for graduate school.
5. It has been difficult to find a good fit between many MI faculty and scientists at research facilities. MI faculty are often not current in their research experience and require time to retool their skills. Scientists at research facilities are often under time and budget constraints that do not lend themselves to extended periods of mentorship.
6. A number of programs and agencies discuss the importance of MIs partnering with research institutions, yet there is a paucity of incentives to motivate the researchers to commit to such collaborations. A reasonable question to ask is, "Why should an active researcher spend valuable time and resources mentoring faculty from MIs?"
7. Funding agencies are increasingly offering large funding opportunities to MIs that are not faculty initiated, but rely heavily on MI administrators to develop and implement the program. This approach is more likely to fail since it does not involve the faculty-level expertise essential to developing realistic and achievable goals.
8. Recently there has been a general decrease in funding by NASA and other agencies that targets "small science" and/or small institutions.
9. In some instances it has been difficult to recruit students attending MIs to participate in summer programs at distant NASA centers and other facilities even when such opportunities are available. These students tend to come from backgrounds with little or no travel experience and limited exposure to individuals from different cultural and ethnic backgrounds. Such students are hesitant to travel far from home.
10. Typical faculty teaching loads at MIs, like most undergraduate institutions, are four courses per semester. Even if funds are available for 25-50% release time, the heavier academic workload at MIs makes it difficult to produce significant outcomes during the academic year. Summer productivity is higher, but the time frame is short.
11. The production of peer-reviewed publications at the MIs has been lower than expected due to the barriers discussed elsewhere in this section. Without such publications the MI researches have greater difficulty being accepted as equals by their peers in the field.
12. The MIs have experienced significant internal barriers to interdisciplinary collaborations. Typical institutional turf wars and power struggles have contributed to under productive programs, even when the administration is involved at the level of the Dean or Vice President.
13. MIs generally do not have adequate research administrative infrastructure, from procurement to human resources. The inability to respond quickly and effectively to research needs makes the MIs less competitive.
14. MIs typically have few resources, financial or otherwise, to support and sustain projects. Once the agency funding ends so does the program it supported.

SUMMARY OF LESSONS LEARNED

The range in type, scope and reporting requirements of the twenty-four funded projects discussed herein as well as other activities at the four schools, do not lend themselves to be examined using a standardized set of criteria and data. Instead, we present a number of conclusions based on our collective experience. We present these lessons learned as a means by which to better understand what does and does not work in promoting the geosciences at MIs.

1. A successful partnership is one in which all members make meaningful contributions to the project.
2. A successful partnership requires mutual respect among all participants, recognizing that strengths and weaknesses exist at each institution.
3. A partnership with an MI is more likely to succeed if the collaboration invests in the long-term development of the institution or the faculty at the MI. Partnerships based solely on access to students at MIs are not as successful or lasting.
4. Implementation of new programs at MIs is often a slow process and occurs in stages. One must allow more time for success to take hold than might be necessary at a research institution.
5. Success in program implementation is far more likely if there is flexibility on the part of the funding agency in allowing the MIs to develop programs that support institutional goals while achieving the objectives of interest to the agency.
6. MI faculty must recognize that internal and external collaborations are vital to success for a variety of reasons, including limited resources, outdated equipment, inadequate infrastructure and lack of a "critical mass" of faculty in the field of study at an individual MI.
7. Students at MIs are highly motivated by hands-on research opportunities.
8. A two-tier approach to research for MI students is very effective. Students with weak backgrounds can obtain necessary skills and develop confidence with an initial internship at an MI before a second internship at a research institution.
9. The most effective route to recruiting students at MIs is through partnering with the faculty at the institution because of the close mentor-student relationship that exists at MIs.
10. MIs can serve as a point of contact to the public and the K-12 communities. Strong ties and a bond of trust exist among these groups.

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