TUSKEGEE MSP-A SUCCESS STORY

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Abstract

A partnership consisting of institutions of higher education in Alabama, school districts in the state's Black Belt region, along with other organizations is actively working to improve science education in grades 6^{th}-8^{th} in these districts. The partnership is supported through an award by the National Science Foundation, under the Math and Science Partnership (MSP) program. It is led by Tuskegee University and consists of four doctoral granting institutions, five community colleges and ten school districts in the Alabama's Black Belt region, serving 82 science teachers and 8000 students in 6^{th}-8^{th} grades. A key activity is the development of NanoBio science-based course modules and 3-D simulation of science concepts by STEM and education faculty and master teachers for delivery in an inquiry-based setting in the partner schools.

This paper describes the forging of the partnership, the interventions that are designed to address challenges in science education in the partner school districts, and the project's implementation and research framework.

Introduction

In June 2008, a Math and Science Partnership – Start (**MSP-Start)** grant, under the title "*Minority-Teacher Led Program Partnership Model for Integration of NanoBiotechnology among Research Centers and the K-12 Classroom",* was awarded by the National Science Foundation (NSF) to a consortium of Universities in Alabama led by Tuskegee University. The partnership among these institutions was based on the expertise of their faculty in research, education, and outreach in NanoBio Sciences and the collaborative manner in which these institutions have worked over the last two decades to enhance the research competitiveness of the state through the NSF-funded Experimental Program to Stimulate Competitive Research (EPSCoR) and other federally sponsored grants and contracts. NanoBiotechnology is also an area which is heavily invested ($2.1 billion) by federal sources as indicated by 2007 NSF survey of federal funds for research and development **[1]**. NanoBio Sciences, an emerging field of research and education, was chosen as the central theme of the proposed project because it is the fundamental building blocks of science and mathematics. It is also a discipline which can easily capture the attention of young minds.

The focus of the MSP-Start grant was to:

- Examine the performance of K-12 students in science courses in schools in the Black Belt region of Alabama and then identify the school districts and the grade levels for project interventions;
- Examine teacher quality, quantity and diversity in target school districts; and
- Form a partnership including the target school districts, doctoral granting institutions, community colleges and other organizations that are committed to ensuring that all students in these districts have access to, are prepared for, and are encouraged to participate and succeed in challenging and advanced science courses.

Because the original project was based on a far-reaching effort to form a state-wide partnership in Alabama centered around the EPSCoR funded NanoBio Science and Sensors activities, stakeholders from these centers and others in the academia, industry, state department of education and K-12 school systems were invited to participate in the initial meetings. The project team consisted of volunteers viewed as either making or having the potential to make substantial impact on K-12 science education, promoting and "seeding" scholars for future careers. Working together, the ultimate objective of the partnership was to have *all* Alabama students prepared and well-grounded in math and science technology improving the economic landscape for future scientists, researchers, and technicians **[2]**.

As originally envisioned, this project cast a broad state-wide net but always centered on the enhancement of math and science achievement of minority students in the state of Alabama. Over the course of its development, the project was refined to have a regional focus but the leadership role never wavered. Nevertheless, the project did result in state-wide benefit by generating interest among the participating institutions spawning a few other proposals on a similar concept. This paper examines how the partnership evolved and developed along with the project final outcomes specifically with respect to the protocol for establishing the partnership, teacher training, research, and the development of pedagogical materials.

Background

Math and Science Partnership (MSP) programs are supported by the NSF as a means of 1) Ensuring that all students are adequately prepared to participate and successfully complete advanced courses in mathematics and science; 2) Enhancing the quality, quantity and diversity of mathematics and science teacher workforce in the K-12 system and 3) Developing evidence-based outcomes which will enable us to develop a better understanding of how students comprehend and retain mathematical and scientific concepts **[3]**. The MSP-Start grant provided seed funding at $300,000 for a period of two years to examine key features in developing a partnership.

Basic theory for K-12 and higher education partnership development is well documented in the literature. Kingsley **[4]** describes partnerships as being a popular means of implementing public programs by which resources and knowledge are used to achieve goals that are distributed across multiple actors. Results by Caton, et al. **[5]** found that collaborations between teachers and research scientists can positively affect the environment for learning science in precollege and college classes. Moreover, successful collaborations are most likely to occur when equal status for teachers and scientists in the partnership is stressed and partners have the opportunity to explore inquiry-based curricula together. Brinkerhoff **[6]** found, initial work must be conducted to identify partners closely bound, sharing common goals, sharing liability and risk, and having mutual interests in adapting behavior in pursuit of shared objectives. Yet, as Schiavo and Miller **[7]** conclude, forming sustainable partnerships is about weighing trade-offs. Such trade-offs were seen in the MSP-Start partnership development primarily from shifts in emphasis from the state-wide ambition to a more regional focus. The final outcome contained elements originally envisioned; however, in final form effectively had a much different flavor.

The working group in the MSP-Start project initially involved a team of key leaders from 1) the academia including Tuskegee University, Alabama A&M, Alabama State University, Auburn University, University of Alabama, and University of South Alabama; 2) EPSCoR NanoBio Science and Sensor Directors from across the state; 3) Representatives from the Alabama Math, Science and Technology Initiative (AMSTI); 4) selected school districts; and 5) the HudsonAlpha Institute for Biotechnology, a major biotechnology industry in Alabama. The project team envisioned the development of a statewide "network of networks" to establish vital links between higher education, K-12 education, and industry for developing new pedagogy and education outreach programs **[8]**.

MSP-Start Activities

The process for developing the Alabama NanoBio Science Partnership involved three primary phases: a needs analysis; building a community of partners with common interests; and follow-up focus group meetings. However, these phases were guided by a series of programmatic goals established by the partnership as conceptual targets for the program. Each goal was slated to benefit the sectors of education and research.

The first goal was aligned with the State of Alabama's education goals which was to increase STEM offerings by 60%, increase STEM course enrollment by 70%, and double Advanced Placement (AP) qualification scores **[9]**. The second goal was aligned with the state's research program goal to identify and recruit students in STEM fields through the development and introduction of nano-biotechnology pedagogy; provide teacher training and professional development programs; create a state clearinghouse for nano-biotechnology education; and form partnership linkages for pipeline development **[10]**. Finally, the third goal was aligned with the state's workforce goal which was to prepare workers for new industries drawn to Alabama in biotechnology, robotics, and nanotechnology. This final goal is in concert with efforts of the Alabama Workforce Development Office leading to a need for new designs for student preparation and state workforce development to meet industry demands. To achieve these goals, the partnership outlined a series of objectives for the project. They were 1) to improve K-12 programs by raising student achievement; 2) to change higher education culture through training of STEM faculty in education and research; and 3) to research and evaluate a partnership model for incorporating research-based activities into other K-12 programs.

Once the skeletal framework of goals and objectives was formed, the partnership focused on assessing student, teacher, and partner needs (i.e., the needs analysis). The preliminary plan involved a stepwise series of activities, beginning with a series of meetings in the Spring of 2009 involving a number of perceived and interested key players. The focus of the meetings was to answer two primary questions: 1) *What are the current STEM needs of the public education system? 2) How can STEM research programs help meet those needs?* The plan was to seek answers through four sessions which were on A) building community; B) establishing core collaborative values for the partnership; C) setting roles for each member; and D) defining sustainability for the partnership **[11]**.

During the initial sessions the team addressed the Alabama Course of Study as the guide to creating new STEM content for the K-12 pipeline. Earlier in 2007 the Industry Education Director for HudsonAlpha began the process of working with the State for introducing Biotechnology content into K-12 pedagogy. Although this work served as a process template for collaboration, agreement as to the "nanobio content" was problematic. Researchers were unfamiliar with K-12 contextual needs and K-12 teachers and administrators addressed a steep learning curve to understand emerging technology concepts. To bridge this knowledge gap a novel approach was employed to ensure students and educators were active in the program development process by asking each to provide their perception of STEM learning to the other. It was acknowledged that researchers may not have close contact with K-12 students as a matter of practice, nor are students expected to fully understand what is encompassed by STEM research. Researchers must understand the student's point of view when it comes to learning, especially regarding matters of delivery (it cannot be boring), and content (it must be understandable and relevant). The mechanism for this dialogue was a suite of summer projects with participating school districts and researchers focused on interactions with teachers and students, one-on-one or in groups, simply to discover what motivates or interests K-12 students in science and mathematics. This was challenging since most K-12 collaborating schools did not possess resources to host workshops addressing NanoBio concepts. In some cases it was more feasible to host projects at universities. Projects developed simple experiments or concepts relative to research to show students and teachers what researchers believed would be enjoyable containing basic science principles from their work tied to important ideas in emerging technologies.

Ten summer mini-projects were funded through the MSP-Start grant to encourage collaborative activities and concept development. To collect quantitative data, solicitations for projects had to include information on the proposal team members and group activities. Individual participation from research and K-12 was required along with a description of how diversity of the teachers and students would be pursued. Industry, private sector, and other collaboration (e.g., science museums, community organizations, etc.) was encouraged, but not required. Content was limited to activities involving K-12 applications for nanotechnology, nanobiotechnology, and/or sensor technology aligned with the Alabama Course of Study. Projects concluded with presentations to the MSP-Start leadership. Once the mini-projects concluded and their content documented, focus group meetings addressed MSP-Start key features and research questions. Participants met with management groups of currently funded MSPs with similar foci to build upon previous work completed. The relationship established with two national Materials Research Science and Engineering Centers (MRSECs) at Cornell University and the University of Wisconsin was very useful, resulting in a teacher training pilot program held at the 2009 Annual Summer Institute of the Southeastern Consortium for Minorities in Engineering (SECME). The SECME summer institute along with follow-up meetings provided new content as well as 2D and 3D virtual and immersive educational materials in NanoBio science. More than fifty planning meetings were held at various sites during the MSP-Start grant period.

Outcomes: Focused Content and Context

The process was designed to ensure participation of all partners including the K-12 community, higher education, industry, and civic organizations to identify and prioritize the needs with respect to student advancement in STEM programs. The leadership team realized that geographic locations of higher education participants and K-12 school districts would lead to the dilution of effort and reduction in the program impact. The team's focus therefore changed into a more refined initiative engaging some of the original partners but having a smaller regional focus within the geographical proximity of the lead institution and placing emphasis on minority populations.

Focus was originally placed on the testing of students' content learning in science. It was planned to use the discoveries in NanoBio research to motivate students and to enhance their comprehension of science concepts. Due to limited knowledge on the part of teachers in NanoBio science content combined with limited knowledge of STEM researchers of K-12 educational needs, the focus was shifted to teacher/researcher pairing for collaborative learning.

Summer mini- projects allowed participant flexibility in identifying the most promising methods for addressing teacher professional development and assisting STEM researchers in the understanding of the Alabama Course of Study needs. Projects included teacher professional development and training programs with STEM researchers developing hands-on inquiry based content tied closely to the Alabama Course of Study with classroom lecture and laboratory modules. At the 2010 SECME summer institute held at Clemson University, some of the mini-projects were presented to the teacher participants to learn about their effectiveness and teachers' reactions. Ten minority teachers from Alabama were sponsored through the MSP-Start grant to participate in the institute providing training and evaluation comparison **[12]**.

Lessons Learned from MSP-Start

Upon examining student performance data in science in the partnering districts, the MSP-Start leadership team noted that need is present in schools in many areas and at many levels. However, while working with science teachers, school district officials, and AMSTI, it became apparent that the project's interventions should be directed towards addressing a particularly poor performance in science education at the middle grades (grades 6-8). Teachers in this grade band report that their students begin to exhibit unfavorable attitudes and lack of interest and motivation to learn science. In addition, the MSP-Start team noted that classroom practices by science teachers lack the inquiry-based pedagogy which research shows is desirable for favorable student learning outcomes in science **[13]**. Moreover, many of the partnering schools do not have suitably-equipped laboratories so that students get a feel for doing science. These shortfalls in teaching methodologies and resources contribute to students' dislike of science. Research also shows that students must learn an early appreciation for academics, in particular the sciences because interest, motivation, and achievement in science declines dramatically during early adolescence and especially during the seventh grade **[14]**. Therefore, the project leadership team decided that it should focus its efforts in addressing the needs of partnership schools in science education in grades 6-8.

The Southern Black Belt is a term that was first used by Booker T. Washington, founder of Tuskegee University, to describe the color of the rich southern soil on which slaves worked. This region is a collection of eleven southern states stretching in a crescent shape from Maryland to Texas. The portion of the Black Belt region that falls in the state of Alabama is comprised of twelve predominantly rural counties that are rich in cultural traditions. The area became a hotbed of activities for the civil rights movement and the **historic march** for equal rights from Selma to Montgomery in 1965. However, the Black Belt of Alabama is also a region that has long been characterized by low socio-economic conditions. The region suffers from a high poverty rate with 29.5% of the population living below the poverty line, 13.3% higher than the state average **[15]**. Sixty-five percent of the Alabama Black Belt is populated by African-Americans, of whom 32 percent live in poverty, twice the Alabama average. The median household income is 30%

below the state average. Research shows that there is a strong correlation between weak socio-economic indicators and low education attainment **[16]**. Such is the case in the Alabama Black Belt where 45% of the region's citizens over 25 years of age have not completed high school. Stanford Achievement Test (SAT-10) scores are dismal and consistently among the worst in the state. This is particularly true with regards to science education achievement. In the ten Alabama Black Belt school districts that are partnering in this project, the average grade 7 SAT-10 score in Science in 2008-2009 for all students is **21.6** percentile points lower than the state average.

Disparities in the performance among various subgroups of the student population at the middle grades in the partnering school districts are troubling. Blacks in all districts are being outperformed by their white counterparts, and their percentile placement is lower than the average percentile for all blacks in the state. Those students who qualify for free and reduced lunch (an indicator of poverty) are performing much below those who are not eligible, and their overall percentile scores are significantly lower than the corresponding average for the state. Whereas the SAT-10 state average percentile score in each category has steadily increased over the three year period between 2006 and 2009, six of the nine partner school districts have shown the opposite trend. The Bullock, Montgomery, and Lee County school districts have seen slight improvements.

An analogously bleak picture emerges when we examine the Alabama Science Assessment (ASA) test scores which Alabama introduced in 2007-2008 to test students in science in grades 5 and 7. The ASA measures how well students are mastering specific skills defined by the state of Alabama. It shows the level of proficiency a student demonstrates in meeting state standards. Students are rated at one of four levels: I) does not meet, II) partially meets, III) meets, or IV) exceeds content standards. Students are considered to have passed the ASA if they score at level III or IV. Although some improvement was seen over the period 2007-2008 to 2008-2009, a large proportion of the students tested in 2008-2009 were placed in either level I or II (see Table 1 below). In addition, we note the same disparities in performance among various subgroups of the population as in the SAT-10 examination.

District	Barbour	Bullock	Dallas	Lee	Lowndes	Macon	Montgomery	Perry	Selma	Wilcox
Levels I & II	61%	38%	63%	33%	67%	52%	42%	42%	60%	48%

Table 1: Percent of students performing in either level I or II, ASA, grade 7, 2008-2009.

In terms of **quality, quantity, and diversity of science teachers**, the partnering school districts report that all middle grades science teachers are certified in the state of Alabama for classroom instruction; a large proportion of them however (38%) are not Highly Qualified in science. Thus, it appears that overall teacher preparation in middle grades science in the partnering school districts is an issue. Regarding degree attainment, 30 teachers have a Bachelor's degree and 48 of them have a Master's degree. Teacher ethnicity is reflective of the region's demographics, with 64 African-American teachers and 14 Caucasian. Moreover, the science teaching force in the middle grades is fairly experienced with an average of 11 years in the teaching profession. Teachers have an approximate average of 95 professional development hours, indicating that they have availed opportunities to participate in activities to improve upon their qualification after receiving their certification. In addition to an unsatisfactory number of Highly Qualified teachers, the Superintendents of participating school districts unanimously agree that all middle grade science teachers must learn to use instructional strategies in the classroom that go beyond the conventional approaches such as lecturing and rote memorization which students find highly unappealing. Through the MSP partnership, teachers are being be trained to use (1) instructional methods that are inquiry-based to fully engage students in the learning process; and (2) resources that are being developed as part of this project including curriculum modules rich in NanoBio principles and exciting 2D and 3-D simulations to demonstrate hard to understand science concepts. Teachers are thus be better equipped to provide high quality instruction that is based on the best available research in science education. In the process, students are better motivated and are building confidence in their scientific abilities. This will in turn have a positive impact on achievement in science standardized tests such as the ASA where more students will perform at levels III and IV and the SAT-10 on which a larger portion of the student population will perform at levels that are closer to the state averages for each category.

In summary, the MSP-Start grant allowed the project team to understand that there exists a critical need to 1) provide additional assistance in preparing students to perform better in science courses; and 2) enhance K-12 teacher quality and quantity. The team found that there is a sufficient number of committed STEM faculty who are willing to work collaboratively in meeting the needs of the K-12 system. It was also realized that, in view of the limitation of resources, it was essential to focus on a smaller high-need region of school districts rather than to work with schools districts throughout the state of Alabama.

Partnership Development

Based on the lessons learned a new partnership and project title evolved. The title of the MSP project was chosen as "**A NanoBio Science Partnership for the Alabama Black Belt Region**". The partners identified for this project are shown in figure 1. The core project partners include five Universities, five Community Colleges and nine K-12 school districts described below.

a. University Partners

i. Tuskegee University (TU): TU is a Historically Black land-grant University that was founded as a normal school for training teachers. Over the years, TU has transformed into a major university that offers a variety of undergraduate and graduate degrees ranging from the liberal arts, including teacher education to advanced STEM disciplines. TU has been chosen to lead this partnership because of the expertise of its faculty in fundamentals of NanoBio Science and Engineering. Moreover, TU faculty members have developed and offered several research and educational programs for K-12 students, teachers and college students leading to the Doctorate in Materials Science and Engineering.

ii. Auburn University (AU): AU is a comprehensive, Research-I, land-grant institution that offers degrees at the undergraduate, graduate, and professional levels. AU's role as a land-grant university emphasizes research in areas that include the biological sciences, engineering, physical sciences, education, the liberal arts, and human sciences. Auburn's land-grant mission also includes a responsibility to extend knowledge beyond its campus and apply research in a direct, practical way to the community.

iii. Alabama State University (ASU): ASU is a state-supported, Historically Black institution providing education and research to citizens of Alabama and the United States. The University offers degrees at the associate, baccalaureate, Master's, and Educational Specialist levels and Ph.D. degrees in Environmental Microbiology and Educational Leadership. In recent years, ASU has built a solid NanoBio research infrastructure.

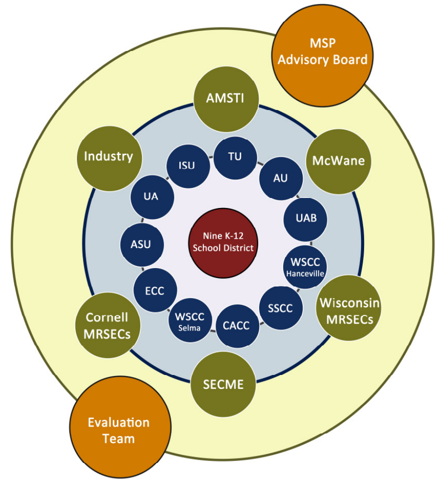

Fig. 1: The NanoBio Science Partnership

iv. "Indiana State University (ISU): ISU was established by the Indiana General Assembly in 1865 as the Indiana State Normal School in Terre Haute. As the State Normal School, its core mission was to educate elementary and high school teachers. In 1965, the Indiana General Assembly renamed the college as Indiana State University in recognition of continued growth. The Princeton Review has named ISU as one of the "Best in the Midwest" seven years running, and the College of Education's Graduate Program was recently named as a 'Top 100' by U.S. News & World Report. ISU has a nationally known Center for Science Education, located in the College of Arts and Science. The Center is a focal point for a number of innovative programming, research and outreach activities. The faculty of the Center for Science Education has expertise in the field of teacher learning in STEM.

v. The University of Alabama (UA): UA is Alabama's oldest public university. UA's mission is to advance the intellectual and social condition of the people of the State through quality programs of instruction, research, and service. UA has developed extensive research and educational programs for K-12 students and teachers by providing them great opportunities to learn advanced science and technologies.

v. The University of Alabama at Birmingham (UAB): UAB is a public research university whose engineering faculty has a solid track record of pursuing cross-disciplinary programs of research, education, technology-transfer, and outreach in high fidelity computational field simulations and associated enabling technologies. UAB's expertise in 2 and 3D modeling and simulation plays an important role in the teacher training component of this project.

The Five (5) Community Colleges whose faculty participants are also playing an important role in teacher training and recruitment of prospective science teachers from within its student body are described below. They are also working collaboratively with UAB in the development of 3-D simulation of science experiments for students in 6^{th}-8^{th} grades:

i) Central Alabama Community College (CACC), ii) Enterprise State Community College (ESCC), iii) Shelton State Community College (SSCC), iv) Wallace State Community College (WSCC), Hanceville, and **v) Wallace State Community College (WSCC), Selma**.

The involvement of these Community Colleges in this partnership is desirable because a large number of students opt to go to these institutions prior to transferring to a four year institution. According to the 2008-2009 Chancellor's Report of the Alabama

Community College System, **38%** of college-going students were enrolled in Associate of Arts and Associate of Science Programs throughout Alabama with **30.70%** of them being minorities. Further, these institutions have active collaborations in student development activities with the university partners as well as growing IT and virtual training programs.

b. K-12 School District Partner

Nine of the ten school district partners are located in the economically and educationally underserved, yet historic, Black Belt region of Alabama. The participating school districts in the Black Belt are Barbour, Bullock, Dallas, Lowndes, Macon, Montgomery, Perry and Wilcox Counties along with Selma City (located within Dallas County). The Lee County school district, a territory that falls outside the Black Belt region, and shares a common border with Macon County, is also a school district partner. It was included in the partnership because of its close proximity to Auburn and Tuskegee Universities.

c. Supporting Partners

In addition to core partners, a diverse group of **supporting partners**, shown in Figure 1, is instrumental in meeting the goals of the partnership. A brief description of these partners and their roles are described below.

i) Alabama Math, Science, and Technology Initiative (AMSTI) is an Alabama Department of Education initiative whose mission is to improve math and science teaching statewide so that all students develop the knowledge and skills necessary for success in postsecondary studies and in the workforce. Senior members of AMSTI actively participated in the needs analysis and partnership development process under the MSP-Start grant. Their involvement is critical in guiding the MSP team during the development of curriculum modules and other intervention activities so that state standards for 6^{th}-8^{th} grade education are met.

ii) McWane Science Center is a non-profit organization, which gets its name from the McWane family and McWane Foundation. McWane Science Center has welcomed millions of visitors since opening its doors in 1998. People visit year-round to see, to hear, to touch, and to experience the wonder of science. Through the MSP-Start grant, faculty participants have visited the Center several times and examined the educational modules, displays, and hands-on activities that are offered by the Center to the Alabama community. The Center tests curriculum modules that are developed by the MSP project for their effectiveness and will incorporate them as part of their exhibits as outreach to the community.

iii) Materials Research Science and Engineering Centers (MRSECs) are research and education centers funded by the NSF, through the Division of Materials Research, which have research, education, and outreach as their key components. These centers have developed and tested several curriculum modules to assist K-12 students and teachers in developing a better understanding of math and science courses. MRSECs make these modules freely available to K-12 teachers through their lending libraries. Tuskegee University has developed a long term collaborative relationship with MRSECs at Cornell University and the University of Wisconsin, which includes joint research, student and faculty exchange, and outreach to the K-12 community.

iv) Southeastern Consortium for Minorities in Engineering (SECME) was founded by six engineering colleges in the southeast including TU and UA. Its mission is to increase the pool of underserved and under-represented students who will be prepared to enter and complete post-secondary studies in science, technology, engineering, and mathematics (STEM); thus creating a diverse and globally-competitive workforce. Today, SECME works with **40** engineering Colleges, **more than 50** school districts, **42** corporations and foundations, and **more than 5,000** K-12 students in **15** states, the District of Columbia, and Grand Bahamas Island. SECME will be the main vehicle through which science teachers from partnering districts in the MSP project will receive training. Sessions tailored for school district administrators will also be held.

Program Content

The partnership has set the following goals for the MSP project:

- To increase the science achievement and interest levels of all middle school students in the Alabama Black Belt region;
- To reduce gaps in the performance in science among the various ethnic, socioeconomic, and gender subgroups of the population;
- To improve the knowledge and performance of in-service teachers through intensive professional development; and
- To recruit highly motivated students including community college graduates to become certified science teachers.

The following program elements were proposed to accomplish these goals:

1) Development of curriculum modules;
2) Development of 2 and 3D simulation of science experiments;
3) Training of teachers in the delivery of the modules;
4) Increasing the number of highly qualified science teachers in the Black Belt; and
5) Research and evaluation.

Development of Curriculum Modules

Under the current **MSP Target** grant that was funded in September 2011 (successor to the MSP-Start project), the faculty at AU, ASU, TU, and UA are:

- Developing during the school year, in collaboration with selected science teachers from partner school districts (designated as Master Teachers), the necessary course modules based on NanoBio principles, for all partnering science teachers to use in the classrooms;
- Testing the modules in select classes with the help of these Master Teachers; and
- Delivering the modules to the staff at the McWane Science Center for review of their effectiveness. If the modules are found to be valuable, McWane Science Center includes them as exhibits so that 6^{th}-8^{th} graders from every school may benefit from them.

Figure 2 shows the scheme of module development and implementation.

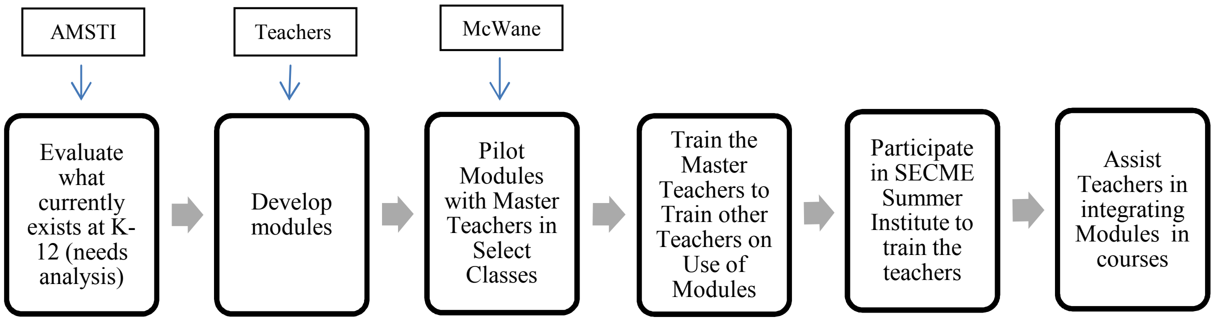

Fig. 2. Schematics of Module Development

As a pilot project funded through the MSP-Start grant, faculty participants at TU created and tested four hands-on science modules in Nanoscience, appropriate for the middle school curriculum (one each for 6^{th}, and 7^{th}, and two for 8^{th} grade), while a multidisciplinary group of faculty members at AU created and tested, with the help of local teachers, another set of modules for 7^{th} and 8^{th} graders involving the structure of carbon nanotubes and their role in treating cancer.

Other pilots hosted through the MSP-Start included nano-water quality experiments and bacterial treatment tests that allowed students to connect issues within their frame of reference, or sphere of influence, in their community to the learning process. Student and teachers paired on projects were provided opportunities for the association of science with such topics as (1) the water they drink, (2) the health of local produce industries, (3) as well as assessing the efficiency of various commercially available chemicals on typical household contaminates ([16], [17], [18]). Both teacher and student participants ranked highly the opportunity to make science content socially and locally relevant as something they could understand and conceptually apply. Pre and post measurement of content learned was higher with respect to that which students viewed as being within their sphere of influence, something they could pursue as a career path or had direct impact on their lives [19].

As part of the MSP project, faculty participants are scaling-up the process of creating inquiry based content both exciting and relevant to students, as well as selecting modules that are available from Cornell University and the University of Wisconsin MRSECs. Staff at these MRSECs is invited twice each semester to train the teachers and faculty participants in the use of their successful modules. There are a total of four training sessions during each year of the MSP project. Staff members of Cornell and Wisconsin MRSECs have presented several workshops to the faculty and teachers under the MSP-Start grant.

Development of 2D and 3D Simulation of Science Experiments

Researchers at the Computational, Simulation, and Visualization Laboratory (CSVL) at UAB and the faculty members at the partnering Community Colleges have the expertise in developing 2D and 3D simulations of any experiment, process, or phenomenon. They have extensive interaction with the 6^{th}-8^{th} grade science teachers to identify the science experiments that are typically difficult for students to comprehend and then develop 2D and 3D simulations accordingly. The teachers are using these simulations to assist students in understanding the objectives of the experiment, the procedures involved, the equipment and tools needed to carry out the experiment, and safety precautions. These simulations will be made available on-line, on CDs, and placed in the library at each participating school so that students may view them and develop a deeper understanding of the experiments. Where possible, socially and locally relevant content is identified and developed as part of this and other phases of the project. The project team members develop a minimum of six simulations each year and train the teachers in the use of these simulations in classrooms and laboratories. In addition, training sessions are held during the academic year and at the summer institute.

Training of Teachers in the Delivery of the Modules

There are four workshops each year for MSP teachers and faculty members to train teachers in the use of curriculum modules and to collect feedback from the teachers on the effectiveness of the modules. In addition, a ten-day annual summer institute, organized by SECME, is held at a central location to provide further training for the teachers. Faculty participants partner with Master Teachers to train all teachers participating at the Summer Institute. The staff at participating MRSECs is also invited to train the teachers, using their own proven modules. Master Teachers are trained in the faculty members' content area, while assisting faculty in developing a pedagogically sound presentation of concepts for all other middle grade teachers.

In year 3 of the project, the MSP Leadership Team will perform a needs analysis of the current state of science education in grades 9-12 in the partnering school districts. This will include examining student performance in science and the quality, quantity and diversity of science teachers at these grades. Based on the results of this needs analysis, NanoBio-based curriculum modules tied to the 9-12 science curricula will be developed following the schematics in Fig. 2. During years 4 and 5 selected 9-12 science teachers will be trained at the Summer Institute on the use of these modules and at sessions during the school year. 2D and 3D simulation of hard to understand 9-12 science concepts will also be created. Inclusion of 9-12 science teachers in the project will ensure alignment in science education as students go from grades 6-8 to 9-12.

Increasing the Number of Highly Qualified Science Teachers in the Black Belt

In an effort to produce a pool of science teachers with exposure to NanoBio Sciences, the team includes Education Departments at ASU, AU, TU for recruiting science education majors who will complete their degrees with a strong exposure to NanoBio Science and Engineering. Each of the four universities aggressively recruits candidates from their feeder high schools and the community colleges in this partnership. Tuition support and research assistantships are available in the grant for science education majors so that the education departments at these four universities are able to attract the most motivated and best prepared students. To earn the assistantships, these recruits are required to work with MSP faculty in this partnership and their graduate students so that they receive exposure to research and education in NanoBio Sciences.

Research and Evaluation

Research for this project has two primary foci. The first focus is on the efficacy of the curriculum modules and 2D/3D simulations for promoting science achievement and interest for middle school students in the partnering schools. The second focus of research is on potential changes to participating science teachers' beliefs and classroom practices. The research questions are:

Research Question # 1: Does participation in NanoBio curriculum modules and 2D/3D simulations result in increased science achievement and interest for middle school students?

a. Does participation in NanoBio curriculum modules and 2D/3D simulations result in significantly higher performances as measured by the Alabama Science Assessment and the Stanford Achievement Test?
b. Does participation in the NanoBio curriculum modules and 2D/3D simulations result in significantly higher performances as measured by a test of science content knowledge, scientific reasoning, and argumentation skills created for the project, but based on established assessments from the literature **[20]**?
c. Is participation in the NanoBio curriculum modules and 2D/3D simulations effective for closing gender, race/ethnicity, and socio economic gaps in science achievement according to the measures above?
d. Does participation in NanoBio curriculum modules and 2D/3D simulations result in significantly higher levels of science interest as measured by an instrument such as the University of Colorado's Children's Attitude Survey **[21]**?
e. What is the evidence from qualitative data (interviews) that students have increased their science achievement and interests through the project?

Research Question # 2: How does participation in Teacher Training and project classroom activities impact middle school science teachers' beliefs and practices?

a. Does participation in the project increase teachers' use of inquiry-based, student-centered and problem-solving strategies?
b. What are the ways teachers' have modified their science teaching beliefs and practices over the course of the project?

Research for this portion of the project is informed by a rich body of literature in the area of teacher professional development, beliefs, and learning (**[22], [23]**). Both quantitative data in the form of a survey and qualitative data in the form of interviews and classroom observations is currently being collected.

Evaluation Plan.

The evaluation plan is tailored to the specific objectives and research questions of the project, focusing on the extent to which the project is implemented as intended and to determine whether the project is meeting established goals and benchmarks (given in the Supplementary Documents section, p. 5). A longitudinal design is used to examine the progress of project participants over time. Comparison groups are used when examining student achievement. Both formative and summative data is used to 1) make cross-sectional and longitudinal comparisons; 2) directly address the project's research questions and outcome goals; 3) and determine the extent to which benchmarks and outcomes are achieved.

- **Formative evaluation data** is currently being collected for each activity to ensure implementation as planned and to obtain feedback for improvement. These data include feedback regarding professional development and refereed reviews of developed curriculum modules. These data inform key personnel on the project about the strengths and weaknesses of the project and what can be done to improve their efforts.

- **Summative evaluation data** is gathered annually to examine the extent to which the project has made progress toward its annual benchmarks. This information consists of student interest and motivation surveys, student achievement data, teacher knowledge and performance data, and institutional data regarding science education certification programs.

Summary

The MSP-Start grant was instrumental in carrying-out critical preliminary work on the project including the identification of three key items: 1) Willing partners in Alabama who can meaningfully contribute to the goals of the MSP program; 2) Areas of need in the state in K-12 education; and 3) STEM faculty who can work collaboratively with education faculty and K-12 teachers to improve teacher preparation. The information that was collected and analyzed was critical to writing a competitive targeted MSP proposal.

Following the productive work that has been accomplished as part of the MSP-Start grant, the partnership is making a positive impact on the teaching of science at the middle grades in the target districts. The development of NanoBio Science-based course modules and 2/3D simulations of science concepts through the MSP targeted grant is providing teachers with novel strategies in the classroom to make science learning exciting for students. The recruitment and training of prospective science teachers by the project will ensure that teacher graduates have a contemporary education formation rich in NanoBio Science. The investigation of the research questions that have been formulated, in conjunction with project evaluation outcomes, will potentially add to the knowledge base on how students best learn science.

In sum, the MSP project will enhance the knowledge of science and teaching methodologies of participating teachers many of whom teach in high-needs schools. As a result, the project will contribute to three very important qualities that NSF strives for in teacher education: quantity, quality, and diversity. Benefits to students include increased knowledge and understanding of science subject matters and as a result, an improved academic performance on standardized and other tests. The project has a potential to make a lasting positive impact on the education of the region and its economy.

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