Minority Student Pipeline

Math Science Partnership

Project Outcomes Report

DAVID MAY, UNIVERSITY SYSTEM OF MARYLAND

2016

Bowie State University 1865 · Prince George's Community College · PGCPS Great By Choice · Towson University · University of Maryland · University System of Maryland

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2016

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Executive summary: Strengthening the pipeline

Through professional development opportunities for teachers, teaching experiences for undergraduates, and challenging course work for high-school students within Prince Georges county, $(MSP)^2$ has helped to prepare and retain minority students in STEM professions.

Programs

$(MSP)^2$ comprised four different strands of activity for different groups of participants:

1. **Elementary and middle-school teachers**: science faculty at UMCP and PGCC developed and provided two different types of professional development programs for teachers, designed around principles of teaching and learning through inquiry science. These teachers impact thousands of students each year.
2. **High-school science teachers** engaged in summer research experiences over five years with UMCP, UMBI and BSU faculty. Staff at UMBI and Towson University established learning communities for participating teachers to learn more about the nature of science, build on their research experiences, and connect them with the thousands of students in their classrooms.
3. **High-school students** were given opportunities to take challenging science courses for college credit through a pair of innovative dual-enrollment programs developed collaboratively by PGCPS, BSU, and PGCC.
4. **Undergraduate students**: Science majors were given unique opportunities to learn about teaching through formal training and guided experiences in teaching in reformed college science courses at UMCP.

Outcomes

Through these programs, the $(MSP)^2$ partnership successfully:

- **Raised student achievement in science**. Scores on the science portion of the Maryland State Assessments increased twice as much in schools with participating teachers.
- **Stopped the decline in student interest through the elementary years**. Students of participating teachers were more interested in science than their peers after instruction.
- **Prepared students for college STEM**. Many students entered STEM programs in college and 80% of them are still there today.

Introduction: What is *(MSP)²*?

The Minority Student Pipeline Math and Science Partnership - *(MSP)²* - was a joint project that brought together several colleges and a large school district in suburban Maryland. The project targeted both teachers and students in one of the nation's largest counties where the majority of people are minorities, in order to strengthen the pipeline of underrepresented groups into degree programs and careers in science, technology, engineering, and mathematics (STEM). Our partnership designed and implemented a multi-faceted effort that included professional development for teachers in fourth grade through high school, challenging college-level science coursework for high-school students, and teaching opportunities for undergraduate students.

Throughout each part of the project, college faculty worked together with teachers and other school staff to deliver programs focused on different stages of the pipeline, from elementary school through college. The principle that guided every facet of the project was *student engagement*. For teacher participants, this took the form of professional development around student-centered, inquiry-based instructional strategies. For students, we created new opportunities for them to engage in science that they might not have otherwise had.

Ultimately, the program helped to increase student achievement in science, stop the decline of student interest in science through the elementary years, and prepare high-school students for college STEM courses and majors.

(MSP)² comprised an integrated set of programs for science teachers, high-school students, and college science majors.

Project details

Lead partner: Bowie State University

Other partners: Prince George's Community College • Prince George's County Public Schools • Towson University • University of Maryland Biotechnology Institute • University of Maryland, College Park • University System of Maryland

Funding: $12.4 Million from the National Science Foundation, through NSF's Math Science Partnership (MSP) program

Time frame: 2008-2014

Intellectual merit:

Research in science education has shown that the use of active, hands-on learning strategies, discovery-based laboratories, and other inquiry-based pedagogies have a positive impact on students' learning and reduce the science achievement gap for underrepresented minorities.[1–4] This is because inquiry instruction, when done properly, is not only a proven method of improving student learning, it is also inherently suited for reducing the achievement gap by requiring the active participation and interactive engagement of all students. (MSP)² was designed around a research plan that compared different models of inquiry-driven professional development for teachers, and that examined the impact of challenging courses and curricula on the STEM minority pipeline from PGCPS into higher education in Maryland and around the country.

Broader Impact:

Minorities are underrepresented in STEM disciplines at every level from secondary science and mathematics courses through graduate school. Lack

of preparation in mathematics and science among underrepresented minority groups in the early elementary grades undermines enrollment and success in secondary-level school programs and, ultimately, in college and career choices later in life. Prince George's County is one of the largest majority-minority school systems in the nation, with 132,000 students enrolled in grades K-12 (76% African American, 15% are Hispanic). If ever this nation seriously hopes to address the opportunities and the challenges of fostering a robust pipeline for bringing underrepresented minority students into STEM professions and fields of study, Prince George's County offers a worthy case study for such an effort. Indeed, the project successfully impacted these students' interest, achievement, and persistence in science.

In the pages that follow, we describe these programs in more detail and the impacts that they had on students and teachers. ●

$(MSP)^2$ participants

Students and teachers participating directly in the project:

Elementary and middle-school teachers: **380**

High-school teachers: **60**

High-school students in college science courses: **More than 300**

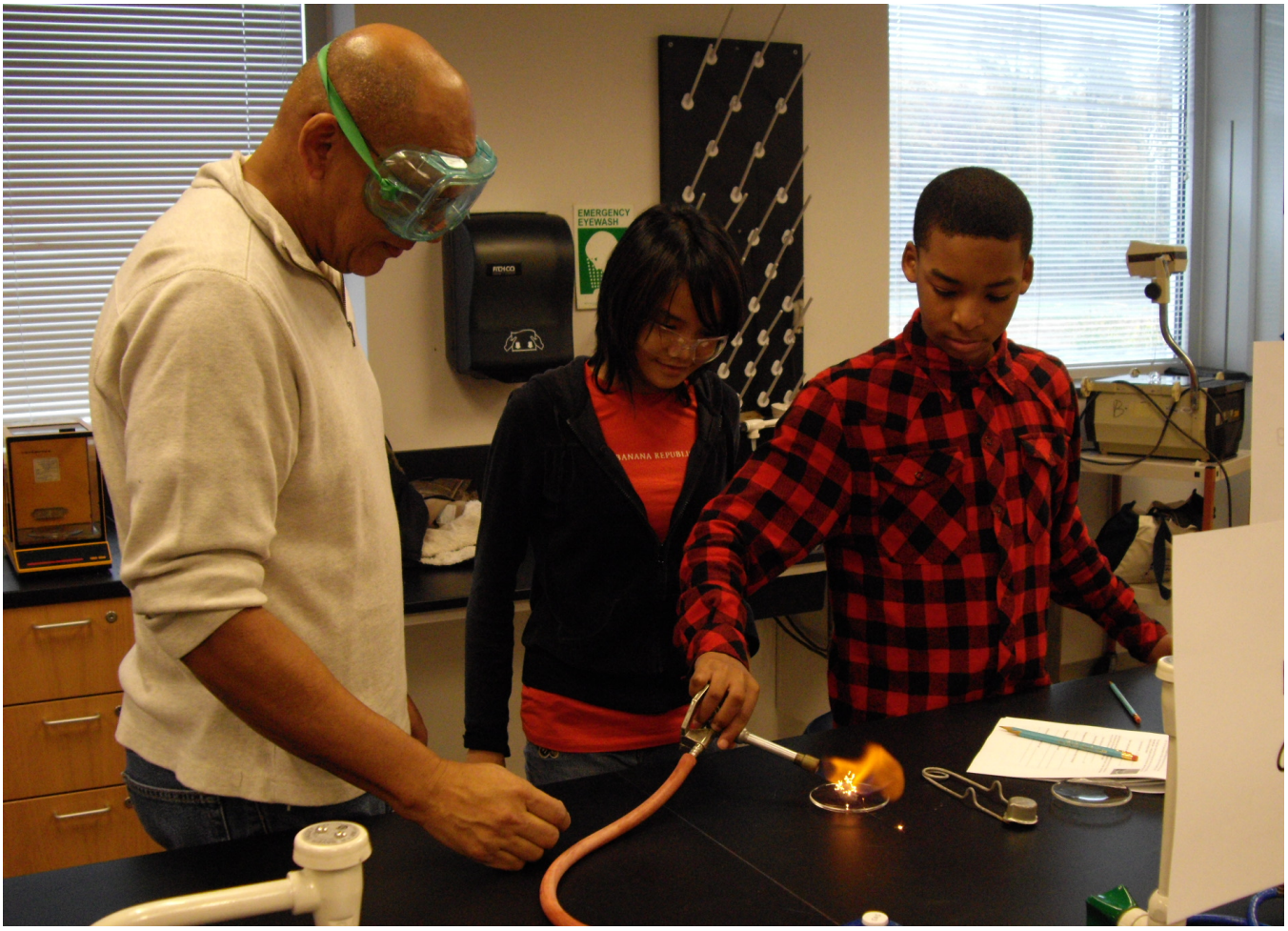
Undergraduate science majors (learning to teach): **70**

Students impacted by participating teachers:

7,600 elementary and middle-school students per year

9,000 high-school students per year

700 undergraduate students per year



Elementary and middle-school teachers

Professional development in science and scientific inquiry

The most current research in teaching and learning demands a rethinking of approaches to K-8 science curriculum, instruction, and assessment. In their significant reports on science education,[5,6] the National Academies of Science and the National Science Board made the overarching recommendation that K-8 education should be coordinated around "doing science."

Based on this recommendation and other important research, faculty at PGCC and UMCP worked with science specialists at PGCPS to design and implement a pair of programs for infusing inquiry instruction into elementary and middle-school science. Each program integrated science content and pedagogy in different ways, and helped teachers apply what they learned to their classroom instruction. Lessons learned from the success of these programs have led the design of similar programs after the $(MSP)^2$ project ended.

PGCC Summer Science Institute

The PGCC Summer Science Institute was a set of two-week professional development programs for teachers in science content and pedagogy led by PGCC faculty. Each institute addressed a different

content area – Chemistry, Earth and Space Science, Life Science, Environmental Science, or Physics – and teachers were invited to return in subsequent years to learn different content. Faculty in each institute modeled and discussed strategies for hands-on inquiry instruction specific to the content area. Approximately 15-25 teachers participated in each institute, for a total of more than 100 each year.

During the school year, participating teachers were given additional professional development and one-on-one coaching by PGCPS science specialists, who met with teachers before and after observing a science lesson in the classroom. Both this coaching and the additional professional development (which took the form of several workshops throughout the year) focused on strategies for incorporating grade-level-appropriate inquiry activities tied to the summer institutes as well as on lesson-plan development and implementation.

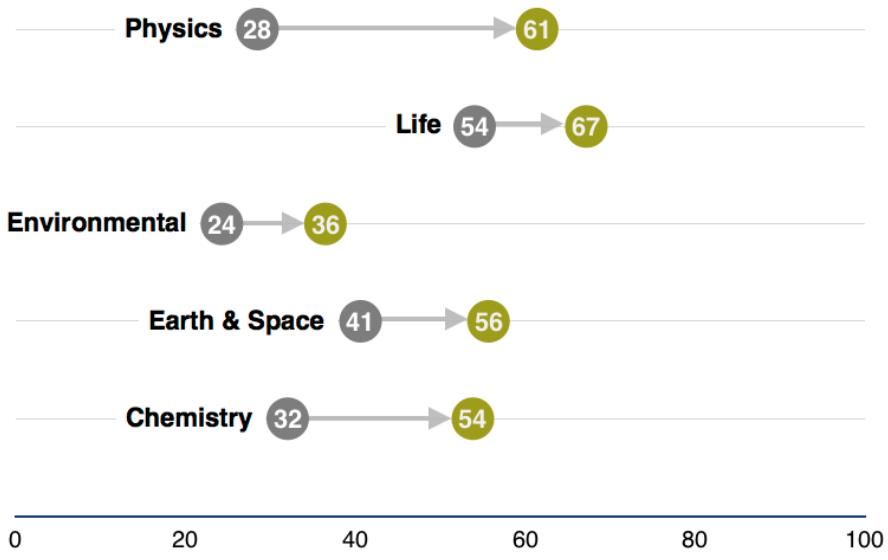
UMCP Science Inquiry Workshops

While the PGCC institutes were rich in science content, the professional development led by UMCP focused specifically on the nature of inquiry and on what it means to do science.

Also beginning with a two-week summer institute (distinguished by calling it the "inquiry" institute), the UMCP program was designed to help teachers listen to their students, not just to uncover misconceptions but also to hear *productive seeds*, the conceptual ideas and the beginnings of scientific reasoning that teachers can encourage and build upon.[7,8] They introduced teachers to *culturally relevant pedagogy* that African-American students bring to school – styles of discourse and pockets of personal experience that are productive seeds of scientific discourse but are not typically recognized as such by schools.[9,10] For example, many African-American students are accustomed to engage in friendly yet spirited debate, an activity connected to a discourse style called *signifying*.[11]

The summer institute helped teachers learn to recognize and build upon the productive seeds in students' individual and culturally-based knowledge. Faculty at UMCP led the institutes and several school-year follow-up meetings to support teachers' implementation of inquiry in their classrooms.

Teacher content knowledge increased during Summer Institutes.
Assessments were given before and after each institute.



Outcomes: Gains in teacher knowledge, student interest, and student achievement

To determine the impact of these programs for teachers of grades 4-8, we looked not only at the participating teachers, but also at their students and the students of teachers who did not participate. Key evaluation measures included teacher content knowledge, student interest and attitudes, and student achievement in science, but we also examined the growth of teacher abilities to attend to student thinking and to train other teachers.

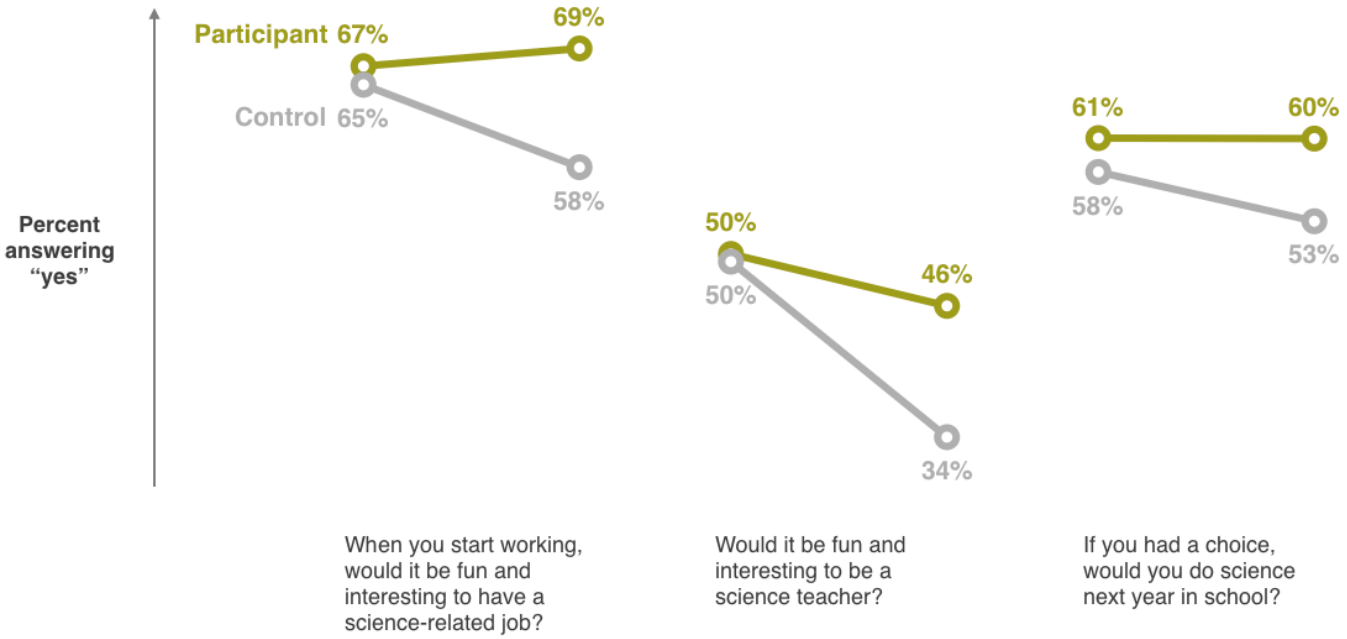
Teacher content knowledge:

In the content-rich PGCC summer institutes, participating elementary and middle-school teachers gained knowledge of key science content. Similar results were achieved in each of the five years the institutes were implemented, in each of the five subject areas.

Student interest in science:

Science, as a subject in school, generally becomes less popular among K-12 students as they get older, particularly in the middle grades. To determine if the $(MSP)^2$ project was able to mitigate this decline in interest, we gave students short surveys, asking if they would like to keep learning science in school and if they thought a science-related job might be interesting. Our evaluation found that students in grades 4-8 whose teachers were $(MSP)^2$ participants did indeed sustain higher levels of interest in science

Students of participating teachers are more interested in science than those of other teachers after a year of instruction.
The same trend appears in three different questions probing interest.



than students of non-participating teachers.

Student achievement in science:

To measure student achievement in science and determine the impact of the $(MSP)^2$ project, student pass rates on the science section of the Maryland State Assessment (the MSA, given in grades 5 and 8) were analyzed over a 6-year period, beginning the year before the $(MSP)^2$ project began. These pass rates – the percentage of students whose science score was considered "Proficient" or "Advanced" – were calculated for each school where 5th or 8th graders took the assessment. For each school, we also determined the number of teachers who had participated in the $(MSP)^2$ professional development described above.

We found that while student science achievement increased throughout the county for several years, the increases were significantly greater in schools with participating teachers than for schools without, both in 5th grade and 8th grade. In fact, they were twice as large. Schools with more participating teachers usually showed larger increases than those with fewer participants.

Elementary schools with participating teachers consistently had MSA science pass rates 6-7% higher during the $(MSP)^2$ program than schools without teacher participants. Middle schools with participating teachers usually had 24-28% higher MSA pass rates than other schools during the program.

Participating teachers helped increase their schools' test scores at a greater rate than other schools.

Elementary schools with participating teachers consistently had MSA science pass rates

6-7% higher

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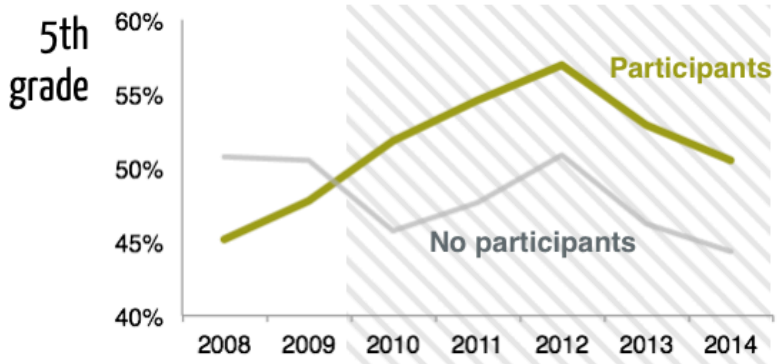

Middle schools with participating teachers usually had MSA science pass rates

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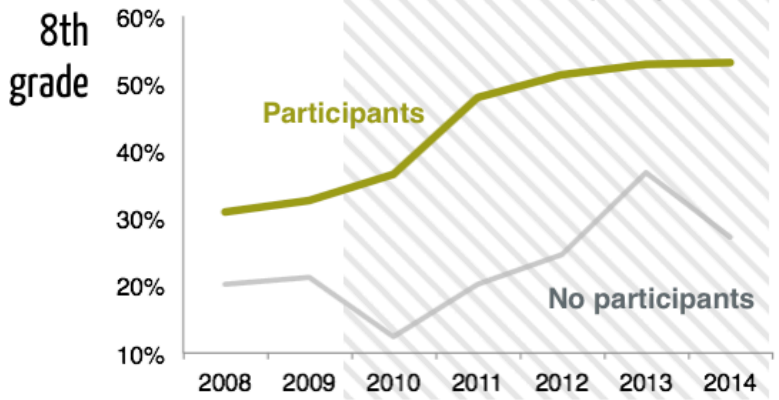


Note that the first $(MSP)^2$ summer institutes began in 2009, so the first MSA exams that could have benefited from $(MSP)^2$ were taken in 2010.

Near the end of the project, MSA science pass rates dropped across the state – this can be seen in 2013 for the 5th-grade assessment and in 2014 for the 8th-grade assessment. The drop in Prince George's County, including for schools with $(MSP)^2$ participants, was comparable to the statewide drop. This drop may be due to the lag between adoption of new statewide standards and the implementation of new assessments – the 12-year-old MSA is not aligned to the Common Core. It is worth noting that the pass rates in schools with participating teachers did not drop as precipitously as those of other schools in 5th grade, and the drop was avoided altogether in the 8th grade.

Sustainability of teacher professional development

The impact of $(MSP)^2$ has been felt at every level of the PG school system, and we are pleased to report that all of the components of our professional development program have been institutionalized in some way. PGCPS now has a model for successful PD, a professional staff of trainers, and valuable partnerships with higher education.

Teacher participation in $(MSP)^2$ positively impacted student success, interest and retention in STEM coursework in grades 4-8, where students' interest normally decreases.

Most importantly, the **teachers** who participated in $(MSP)^2$ summer professional development and completed all three tiers of workshops continue to credit the experience for their increased capacity and capability. These teachers are the core of a new set of trainers who are leading professional development for their peers. Recently, for example, these teacher leaders collaborated with the original $(MSP)^2$ coaches to design and lead a STEM PD workshop series for teachers of grades K-3.

The specific **train-the-trainer model** for professional development created by $(MSP)^2$ has now spread to other academic subjects in the district, most notably in PGCPS's new Literacy Initi ative. Six new literacy coaches have begun supporting teachers across all content areas with reading, writing, and reasoning.

The $(MSP)^2$ **summer institutes** for teachers also have a new life. As part of schools CEO Kevin Maxwell's new Environmental Literacy and Awareness initiative, our successful institute in Environmental Science has been continued with PGCPS funding. The district is also looking closely at the other summer institutes to see how they can be sustained.

Another sustained product of our work on teacher professional development is the research we have conducted and published. Several journal articles, book chapters, and doctoral dissertations include findings from our work with individual teachers and their students.[12–14]

High-school teachers

Learning communities focused on the Nature of Science

Effective instruction in *the nature of science* (NOS) is a state-mandated and nationally recognized learning goal for K-12 science education.[15] Successful students of science should possess an informed view of the nature of science, including appropriate views about subjectivity, the inferential nature of science, the process of inquiry, and other topics. To help reach this goal, the $(MSP)^2$ partnership implemented a program for high-school science teachers called Extended Professional Experiences in Research for Teachers (ExPERT).

ExPERT was a year-round professional development program designed to allow teachers to increase their understanding of, and their ability to teach about, NOS. Through an authentic summer research experience and a professional learning community (136 hours over 11 months) teachers were given the tools and experiences necessary to inform themselves about the nature of science as well as learn the pedagogical content knowledge to teach their students about the nature of science.

The summer research experiences took place in the

laboratories of faculty from several institutions, including BSU and UMCP, for a total of 128 hours over a 4-week period. Several times during the summer and throughout the school year, teachers participated in a learning community led by TU faculty for a total of 136 hours. In learning community meetings, teachers engaged with each other to make sense of the nature of the scientific research they were conducting in the labs, and to think about ways to integrate that knowledge into their regular classroom instruction.

Outcomes: Teachers who can teach the Nature of Science

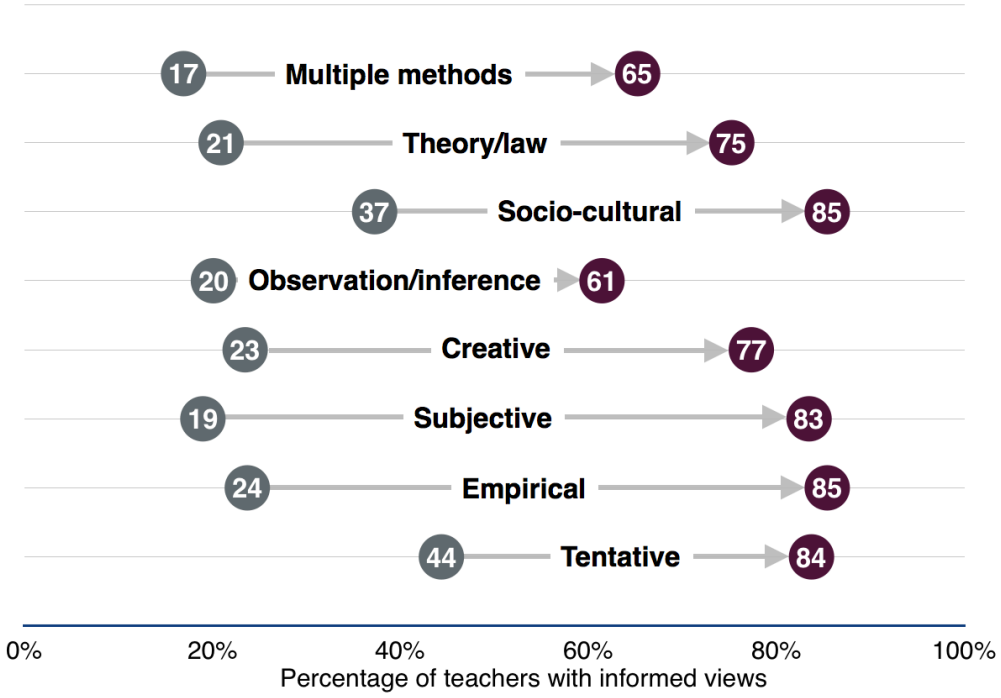
Results of surveys and interviews show that while most teachers entered the program with somewhat naïve views of most topics in the nature of science, they all leave with much more informed views and have a host of techniques for teaching NOS to their students.

Teachers' views on eight different tenets of the nature of science were measured, using a method adapted from research on teachers' views of NOS.[16]

By the end of the ExPERT program, the percentage of teachers with "informed" or "very informed" views on each of these tenets increased significantly.

Almost all of the ExPERT teacher participants (91%) reported that they have learned techniques to explicitly teach nature of science to their students to a "moderate extent" or "great extent." They felt their time in the learning community (as compared to their time in the research lab and their time spent

On all eight tenets of the Nature of Science, the percentage of teachers with informed views increased significantly in each program year.



reflecting and journaling) had the greatest effect on their understanding of the nature of science.

When asked to what extent they explicitly taught nature of science in the classroom during the year, only 60% reported they had done so. This is consistent with research that shows it's usually easier for teachers to change their perspective and understanding than to change their actual teaching practice. Such changes require more sustained and/or focused professional development and support. In the case of ExPERT, the dedicated time for the learning community to meet and discuss teaching strategies seems important for ensuring this type of instruction is implemented in the classroom more frequently.

Sustainability of teacher knowledge and practice

The ExPERT teachers have also taken what they have learned to their colleagues around the state. Most participating teachers have taken on leadership responsibilities in their schools and beyond. Several have become science department chairs or professional developers of science teachers from around Prince George's County. Some have served the Maryland State Department of Education as a Master Teacher in science and/or as a consultant for implementation of the Next Generation Science Standards. ●

High-school students

Dual enrollment in science

Underrepresented minority students often benefit from early exposure to college-credit courses while still in high school. Taking these dual-enrollment courses increases a student's likelihood of earning a high school diploma, enrolling in a four-year institution, persisting to a second semester and second year in college, and achieving a higher grade point average in college than non-dual enrollment students. In addition, programs designed to bridge the transition from high school or community college into college or universities are particularly helpful for bringing first-generation and minority students to college.

The $(MSP)^2$ project included a program to bring these benefits to the students of Prince George's County, specifically in science. BSU and PGCC collaborated with PGCPS to develop multiple early college/dual enrollment science courses for nearly 400 high-school students. Two types of programs were implemented:

1. *A summer residential program*: on the BSU campus, high-school students enrolled for three consecutive summers during their high-school careers. Students took supplemental courses and tutoring in mathematics and college skills along with credit-bearing courses in Biology and Chemistry. In total, 74 students completed the program.
2. *A concurrent-enrollment program*: science faculty from PGCC came to area high schools

and taught credit-bearing science courses during the regular school year, including Environmental Biology and Forensic Biology. A total of 307 students participated.

In each program, students were officially admitted to the respective college, received college credit for successful completion of the course, and received full tuition support from the $(MSP)^2$ project.

Outcomes: Success in college STEM

Altogether, BSU and PGCC awarded more than 3,000 college-credit hours in science to 381 students while they were still in high school. After these students graduated, we were able to track nearly half of them into their careers. Unlike many of their peers, **nearly all of them entered college immediately,** and **more than half declared majors in STEM fields**. In contrast to the typically low persistence rate of students in STEM majors (about half overall and one third of African Americans), **80% of our dual-enrollment students remained in STEM for over one year and/or are still in STEM today**.

These outcomes were the same regardless of which of our two dual-enrollment programs the students had completed.

Several students in the concurrent-enrollment program remained enrolled at PGCC after graduating from high school. Of these students, **51% entered a STEM-related degree program** at some point, 75% of whom remained in STEM for at least a year. This is a much higher proportion than the 14% of PGCC students who are enrolled in STEM programs at any given time at the college.

Sustainability of dual enrollment programs

The successful model for dual enrollment created by $(MSP)^2$ has provided an important foundation for the rapid expansion of dual-enrollment efforts in the district. New and expanded programs, policies, and collaborative partnerships make use of the specific practices, materials, and relationships developed by the $(MSP)^2$ dual enrollment programs.

Most significantly, the **partnership** between PGCPS and PGCC has been dramatically strengthened. The two institutions have jointly formed a Dual Enrollment Committee for strategic planning and implementation of programs, which has now met regularly for four years and uses the findings from the $(MSP)^2$ experience to increase opportunities for students. Several new programs have expanded the reach of our dual enrollment program to other science courses and to many non-science and non-

STEM courses. $(MSP)^2$ leaders Dr. Felicia Martin Latief (PGCPS) and Dr. Christine Barrow (PGCC), each in charge of STEM education at their institution, have continued to collaborate on STEM dual enrollment activities in the district.

New **policies and programs** related to dual enrollment have also been implemented, from the local to the state levels, largely because of the positive impact of the $(MSP)^2$ effort. At the state level, recent Maryland legislation (SB 740) now makes it much easier for students to take dual enrollment courses in all subjects, logistically and financially. In Prince George's County, the district has improved and updated some of its policies and administrative procedures related to college-credit bearing courses (e.g., the plagiarism policy), largely due to feedback from the $(MSP)^2$ dual enrollment experience.

Specific **practices and materials** developed by $(MSP)^2$ continue to be used in the district's expanding dual enrollment programs. For example:

- Dual enrollment workshops for PGCPS teachers and PGCC instructors have emulated the multi-day format, in order to strengthen the relationship building and teamwork that were so important during the $(MSP)^2$ program.
- The parent engagement strategies used by $(MSP)^2$ continue to be used to inform and build the support of the parents of dual enrollment students.
- Documents created for the $(MSP)^2$ programs (applications, handbooks, etc.) continue to be the foundation of dual enrollment interactions between PGCPS and PGCC. For example, the Parent-Student Handbook for Dual Enrollment, developed by $(MSP)^2$, has now been revised and is given to parents and students in other dual enrollment programs. ●

Eighty percent of our dual-enrollment students remained in STEM for over one year and/or are still in STEM today.

Undergraduate science majors

Learning about teaching

While many college students are already in the process of pursuing a science career, many of them do not consider teaching as an option. To help strengthen this important part of the pipeline, the $(MSP)^2$ project found a way to give college science majors formal experiences with science teaching as well as training in the educational principles that underlie it.

The Maryland Learning Assistant Program

Modeled after a successful program at the University of Colorado,[17] the ongoing Maryland Learning Assistant Program at UMCP was developed to help science majors learn more about teaching and get focused guidance in research-based pedagogy. $(MSP)^2$ hired several undergraduate science majors to serve as Learning Assistants (LAs) in transformed undergraduate courses. In these courses, enrolled students interact with one another, engage in collaborative problem solving, articulate and defend their ideas, and explicitly discuss aspects of the nature of science and the nature of learning science. The main task of the LAs is to facilitate small-group interactions among these students, but they also work closely with the professor with various aspects of course transformation and with program leaders on learning the research behind these efforts. Although the LA experience is somewhat different for each undergraduate science course, the experience for all LAs involves three interrelated activities:

1. **Content**: LAs meet weekly with their faculty instructors to plan for the upcoming week, reflect on the previous week, and analyze student assessment data.
2. **Practice**: LAs facilitate collaboration among learning teams of 6-25 students by formatively assessing student understanding and asking guiding questions.
3. **Pedagogy**: LAs from all departments enroll in a special Mathematics and Science Education seminar where they reflect on their own teaching and learning and make connections to relevant education literature.

Outcomes: Transforming instructional practices

Over a four-year period, undergraduate learning assistants have supported the educational transformation efforts across 14 different courses, including courses in astronomy, biology, physics, and biophysics. By integrating LAs into these courses, the LA Program has engaged 22 different faculty members in research-based educational pedagogies as well as science teacher recruitment and preparation. The establishment of the LA Program represents partnerships that have grown among the Department of Physics and the Biological Sciences Program (both within the College of Natural and Mathematical Sciences), the Integrated Life Science Honors College, and the College of Education.

Nearly 70 Learning Assistants have participated in the program, several of them for multiple semesters or years. The LAs and the courses they supported directly impacted approximately 2,800 undergraduate students. (Note that some students may have been enrolled in more than one LA-supported course, so this figure is not necessarily the number of unique students.)

Interviews show that faculty working with LAs value the impact that LAs have on student engagement and student attitudes as well as LAs' impact on faculty's own instructional practices. Faculty members recognize the transformative potential of working with LAs and view LAs as potential levers to effect instructional change in their peer faculty.

The pedagogy course for first-time Learning Assistants has been offered eight times and still occurs every semester. Several LAs have gone on to pursue science teaching careers, and most report significant gains in their understanding of the teaching and learning of science.

Sustainability of the Learning Assistant Program

The impact of the LA Program has been felt across the science departments at UMCP, as course outcomes improve and as undergraduate science majors gain important experience and knowledge of teaching and learning. Colleges and departments see its value, and hope to fully fund the ongoing program into the future. In other words, the program begun by $(MSP)^2$ has now outlasted the grant.

Having an established Learning Assistant Program

at UMCP contributed to UMCP Science Education faculty successfully securing a Noyce teacher scholarship grant from NSF. This grant will further incentivize LAs and other science majors to become teachers as well as contribute to sustaining the LA program over the next few years.

Dr. Chandra Turpen, director of the program, led the first regional LA workshop in Fall 2013 for approximately 40 people who were interested in launching, expanding, or sustaining LA programs at their institutions (including faculty, administrators, graduate students and program directors from across the Mid-Atlantic). This workshop was followed by several other regional LA workshops in different places. Dr. Turpen also co-led the National Learning Assistant Workshop at the University of Colorado - Boulder.

The successes of the LA Program – especially improving student learning, expanding to new courses and new faculty each year, and securing funding from university sources – means it is likely to keep expanding as other departments (at UMCP and around the country) may take on the program.

Final thoughts

One year after the conclusion of the $(MSP)^2$ effort, the National Academies of Science, Engineering, and Medicine released a comprehensive report[18] on the professional development of science teachers across the nation – what strategies are in use, what their impacts are, and what more should be done to make sure science teachers have the support they need to help every student succeed. The report included these seven recommendations for the education community:

1. *Take stock of the current status of learning opportunities for science teachers.*
2. *Design a portfolio of coherent learning experiences for science teachers that attend to teachers' individual and context-specific needs in partnership with professional networks, institutions of higher education, cultural institutions, and the broader scientific community as appropriate.*
3. *Consider both specialized professional learning programs outside of school and opportunities for science teachers' learning embedded in the work day.*
4. *Design and select learning opportunities for science teachers that are informed by the best available research.*
5. *Develop internal capacity in science while seeking external partners with science expertise.*
6. *Create, evaluate, and revise policies and practices that encourage teachers to engage in professional learning related to science.*
7. *The potential of new formats and media should be explored to support science teachers' learning when appropriate.*

The $(MSP)^2$ partnership made use of each of these strategies, but especially numbers 2-5. Our use of research-based strategies, collaboration of college scientists and school staff, teacher leadership, and partnership among education institutions most likely had a strong impact on our outcomes.

More can and should be done to cement these strategies in each institution's structure and policy (e.g., number 6 above), but we are well underway. The next task for building on the partnership's success is to help bring them to scale. Students in school districts around the state and the nation would benefit from programs and structures that draw on the lessons learned from $(MSP)^2$ and many other successful initiatives. In particular, strategies for knitting together key partners to address common issues of professional development and student success should be promoted and expanded.

As for the partners of $(MSP)^2$, the aspects of our project that have been sustained and expanded promise to achieve more for our students, and the solid partnership that has been developed across K-12 and higher education in Maryland will undoubtedly generate and strengthen additional efforts in the future. ●

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