

**Sustaining Improvement Efforts to Deepen
Elementary Teachers' Science Content Knowledge:
The Case of the Puerto Rico Math and Science Partnership**

November 2010

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Prepared for the
Math and Science Partnership Knowledge Management and Dissemination Project
Horizon Research, Inc.
Education Development Center, Inc.
A Math and Science Partnership Research, Evaluation and Technical Assistance project
Funded by the National Science Foundation

Work on the Math and Science Partnership Knowledge Management and Dissemination Project is funded by the National Science Foundation (EHR-0445398). These writings do not necessarily reflect the views of the National Science Foundation.

Introduction

The National Science Foundation's Math and Science Partnerships (MSP) program, established in 2002, involves science, technology, engineering, and mathematics (STEM) disciplinary faculty and K–12 districts in partnerships to improve the quality of mathematics/science education in the participating districts and to add to the knowledge base for education reform more broadly. More than 100 partnership projects were funded between 2002 and 2010, with plans to continue to support additional projects in the future.

The MSP Knowledge Management and Dissemination (MSP KMD) project is charged with synthesizing what the partnerships are learning in each of a number of key areas, and situating those lessons in the broader education improvement knowledge base. Lessons learned about deepening teacher content knowledge have been a particular focus of the MSP KMD work for two reasons. First, the MSPs have devoted a great deal of effort to the professional development of teachers of mathematics and science. Second, professional development is the intervention of choice in many mathematics and science education reform efforts in the United States, with the expectation that enhancing teacher knowledge and skills will lead to improved teaching and learning. Lessons learned about designing and implementing professional development, especially programs that involve STEM faculty, can enable program leaders to be more strategic in their efforts, using resources more efficiently, and addressing challenges more effectively.

In earlier work, the MSP KMD team developed the “Handbook for Enhancing Strategic Leadership in the Math and Science Partnerships” (Weiss, Miller, Heck, & Cress, 2004¹). That document suggests that strategic leadership in mathematics/science education improvement starts with understanding the system one is trying to improve. Strategic leaders then choose interventions that fit with the needs of that system, and are likely to be effective when implemented with the capacity that the partnership either already has or can develop. But capacity is not enough; at the same time, partnerships need to be sure that the system develops the will to improve, which involves getting key stakeholders on board, and ensuring that teachers get a consistent set of messages—from the partnership and from school/district curriculum, instruction, and assessment policies.

MSP KMD has conducted a series of case studies of MSP projects with the strategic leadership handbook in mind as a framework for understanding the partnerships between school districts and institutions of higher education. The goal was to describe how MSP partnerships were designed to foster sustained improvement in mathematics and science education, the nature of the challenges that these partnerships faced, and how those challenges were addressed, to help inform future efforts at system improvement.

This chapter is one of four case reports; it describes the Puerto Rico Math and Science Partnership, a partnership between the Puerto Rico Department of Education and universities across the island, including four units of the University of Puerto Rico system as core partners, and the Inter American University and other private universities as supporting partners. Although the project addressed both mathematics and science across all of the grades, K–12, this case focuses on elementary science. A cross-case analysis can be found [here](#).

¹ Weiss, I. R., Miller, B. A., Heck, D. J., & Cress, K. (2004). *Handbook for enhancing strategic leadership in the math and science partnerships*. Chapel Hill, NC: Horizon Research, Inc., http://www.horizon-research.com/reports/2004/mspta_handbook.pdf.

Vignette

It's a Saturday afternoon, and cars are pulling into the parking lot at the local elementary school. Teachers from across the region are visiting one of the 28 Resource Centers established to support science instruction across Puerto Rico. During their visits, teachers attend content-focused workshops, access the Internet, review and borrow instructional materials, and seek assistance from the on-site Resource Teacher in their science instructional planning. The Resource Teacher housed in the Center has an understanding of available instructional materials and how they are implemented. Teachers have come to depend on her expertise, especially when embarking on teaching unfamiliar science ideas.

The Puerto Rico Math and Science Partnership

In 2003, the National Science Foundation (NSF) awarded a \$35 million grant to the Puerto Rico Math and Science Partnership (PR-MSP). PR-MSP is a partnership between the Puerto Rico Department of Education and four units of the University of Puerto Rico system as core partners. Private universities, such as InterAmerican University and the Pontifical Catholic University, as well as science-oriented organizations, like the International Institute of Tropical Forestry and the Arecibo Astronomy Observatory, were supporting partners. PR-MSP followed on the heels of another NSF grant, the Puerto Rico Statewide Systemic Initiative (PR-SSI), which was funded from 1992 through 2002. Many of the partners in the two grants were the same, as was the vision—to ensure that all K–12 students in Puerto Rico attain high levels of understanding of mathematics and science. To achieve the vision, MSP leaders sought to build the knowledge and skills of K–12 science teachers to provide quality science education to all students.

The cornerstone of PR-MSP's work with K–12 teachers was a system of Resource Centers in each of 10 regions across the island. These sites served as centers for a professional development series, known locally as “capacitations.”² When PR-MSP was in full swing, teachers from 155 participating elementary, middle, and high schools attended six-day summer courses focused around specific science concepts, as well as six follow-up sessions held on Saturdays³ during the school year. Each Resource Center was staffed by a science Resource Teacher and a mathematics Resource Teacher, whose role was to help support the professional development and to enable teachers to visit, borrow supplies, use the Internet, etc. PR-MSP also worked to establish learning communities at each school to support classroom implementation of science education reforms. This case report focuses on the elementary science component of PR-MSP, although work at other grade levels and in mathematics was similar.

The following sections describe the context for science education reform in Puerto Rico; PR-MSP's focus, goals and plans for the work of deepening elementary teachers' science content knowledge; how those plans played out over time; key factors in the implementation of the

²Although PR-MSP leaders and participants referred to professional development as “capacitations,” to professional development facilitators as “capacitators,” and to lead teachers as “leading teachers,” this report uses terminology that is more familiar to readers outside PR-MSP: professional development, facilitators, and lead teachers.

³The Puerto Rico K–12 Public Education System does not permit release time for teachers to attend professional development.

project's efforts; and the likelihood PR-MSP's elementary science education reform efforts will have lasting impact.

The Context for Science Education Reform

A Commonwealth of the United States of America, the island of Puerto Rico is densely populated with nearly four million people, the majority of whom are U. S. citizens. Spanish and English are the official languages; English is a compulsory second language taught in schools and is widely used in business, industry, and education.

The Commonwealth has only one public school district, administered by the Puerto Rico Department of Education (PRDE). Virtually all students in Puerto Rico are classified as Hispanic. Roughly two-thirds of the students attend public schools, which tend to serve lower-income children; nearly all public school students are eligible for the national lunch program. Middle and upper income families typically send their children to private schools, most of which have a religious affiliation.

The University of Puerto Rico system and PRDE have partnered for many years to enhance science instruction across the island. In addition to the PR-SSI grant, Puerto Rico received an NSF Collaborative for Excellence in Teacher Preparation grant (1998–2003) to improve pre-service preparation of science and mathematics teachers. The grant was an alliance of seven universities that together prepare close to 80 percent of all science and mathematics teachers on the island. The PR-MSP Principal Investigator had been identified by the head of a previous science education initiative as a potential future leader, and her involvement in the earlier work helped prepare her for a leadership role in planning and implementing the MSP.

The PR-SSI developed curriculum materials and introduced local standards for K–12 science and mathematics education. These standards were then used as the foundation for the design, testing, and dissemination of an inquiry-based approach to learning. The PR-SSI was more focused on materials and standards than on deepening teacher content knowledge—which would later be a focus of PR-MSP.

The Collaborative for Excellence in Teacher Preparation, on the other hand, focused on deepening teacher content knowledge—although the target population was pre-service teachers. As described in the PR-MSP proposal, the Collaborative's main goal was to redesign teacher preparation programs “to enhance the conceptual understanding of the disciplines to be taught by the future science and mathematics teachers; as well as their mastery of content-specific teaching methodology.”

PRDE had much to gain by partnering with the university system on the various NSF programs. At the time the MSP grant was awarded, PRDE had no funding for science supervisors and offered few opportunities for science education professional development. PR-MSP, then, filled a void in professional development and support for teachers of science.

Another contextual feature that supported the vision of the MSP was the regional structure of both PRDE and the University of Puerto Rico system. When the PR-MSP proposal was submitted, PRDE was divided into 10 regions. The University of Puerto Rico had four participating sites around the island: Cayey, Humacao, Mayaguez, and Rio Piedras. The PRDE regions were grouped into four zones, with each zone to be supported by one of the University of Puerto Rico sites. The participation of Catholic University and Inter-American University as supporting partners provided further capacity to offer regional support to participating schools.

Focus, Goals, and Plans for the Puerto Rico MSP Work

The ambitious goal of PR-MSP, as outlined in the MSP proposal, was to “transform the science education enterprise” at all levels, including K–12 and beyond. This goal was to be accomplished by working primarily through a partnership of the university system and PRDE to increase teachers’ knowledge and skills, and improve their instruction. The original plan for building the capacity and infrastructure to develop teachers’ science content knowledge was to begin the work with 146 schools, expanding to 584 schools (one-third of public schools in Puerto Rico) by the time MSP funding ended. This scale-up was to be accomplished by each of the original 146 elementary, middle, and high schools recruiting an additional school in Years Two–Three of the MSP; and then for each of those 292 schools to recruit an additional school in the final years of the MSP. PR-MSP leaders hoped to establish a regional support structure that would continue expanding beyond MSP funding until all schools in the system were served.

The hope in the long-term, as outlined in the MSP proposal, was to work with all science teachers across the island, ultimately reaching all students. This report focuses on aspects of PR-MSP that were aimed at deepening and strengthening the disciplinary and pedagogical content knowledge of elementary science teachers:

- Developing partnership and support between the university system and PRDE;
- Creating a regional support structure to ultimately reach all teachers and students across the island;
- Developing capacity to provide professional development and support;
- Deepening the disciplinary content knowledge and pedagogical content knowledge of K–12 science teachers; and
- Developing supports for school-level change to support science education reform.

In addition to its work with science teachers at other grade levels and mathematics teachers, PR-MSP included components designed to improve the preparation of pre-service science teachers.

A Partnership Between PRDE and the University System

There are many potential partners that might be incorporated into an MSP plan, including business and community partners, legislators and policymakers, professional subject-matter associations, teacher unions, and educators at various levels of the system. The developers of Puerto Rico’s MSP, primarily university faculty who had been involved in prior NSF education improvement grants, believed the most critical partners in transforming science education were

the university system and PRDE. PRDE was to be a Core Partner in the work from the beginning and, as such, involved in elaborating a vision of science education that would guide PR-MSP's work. The endorsement of other groups was sought and obtained, but PR-MSP leaders focused their energy particularly on strengthening and institutionalizing the partnership between higher education and PRDE.

Past reform efforts had sought involvement of PRDE, but it was generally limited to getting the Department's endorsement for the work. The result was a lack of sustainability when grant funds ended. PR-MSP leaders were determined to approach the PR-MSP differently. For example, the PR-MSP included a PRDE representative on each of the Working Teams that planned and oversaw specific components of the project's work. Said one PR-MSP leader:

We knew we were going to use the [PRDE] standards and we were going to include people from the Department of Education in every single team that we have. At the beginning, all of the retreats we had, we had a lot of people from the Department of Education so everybody knew what we were doing, because from the beginning we wanted to do something that would benefit directly the Department of Education, and the Department of Education would feel ownership for it.

Although MSP leaders devoted attention to building support for the program throughout the PRDE system, including the school and regional levels, for sustainability purposes they were particularly focused on the top levels of the Department to help ensure buy-in during the initiative and institutionalization of the reforms in the future.

A Structure for Regional Support

PR-MSP leaders believed that a regional structure was needed to reach teachers and students across the island. An explicit goal of developing support at the regional level was that regional superintendents would encourage teachers to attend seminars and professional development. As part of their responsibilities, regional superintendents oversaw the participation of teachers in professional development programs, making their support of PR-MSP's work critical in reaching teachers across the Island. Four major "multi-regional partnerships," or zones, were to be established to correspond to the regional sites of the University of Puerto Rico.

Regional Resource Centers would provide convenient locations where teachers from PR-MSP schools could attend professional development and gather materials and resources to implement what they had learned in the professional development. Resource Centers would be established at each level (elementary, middle school, high school) within each of the 10 regions, for a total of 30 Resource Centers. The intent was to establish a structure that would continue after the PR-MSP grant ended, eventually offering MSP-like professional development opportunities to all public school science teachers in Puerto Rico.

Each of the Resource Centers would be staffed by one science and one mathematics Resource Teacher, teachers already employed at the school who would continue their full-time teaching responsibilities. The centers were to be open 10 hours per week—typically after school and Saturdays, allowing time for teachers across the region to utilize its resources. The regional Resource Teachers would both assist teachers in finding and using the available resources and

provide space and materials for the professional development. To ensure that they were prepared for their roles, Resource Teachers were to participate in multi-day training sessions, referred to by the MSP as “residential.”

To provide support to the Resource Centers, PR-MSP established a structure in which the four partner universities within the University of Puerto Rico (UPR) system were identified as “zones.” Each zone was assigned responsibility for certain regions within the PR-MSP: UPR-Cayey and UPR-Humacao were each responsible for two regions while UPR-Mayaguez and UPR-Rio Piedras were each responsible for three regions.

Professional Development Capacity

To develop capacity to offer the type of professional development envisioned by the project, a train-the-trainers model was planned to prepare university faculty and “exemplary teachers,” including both active and retired exemplary teachers, to develop the activities and materials for the professional development. The training of trainers would occur in two-day retreats and follow-up sessions during which exemplary teachers and professors would jointly prepare curriculum materials and assessment activities. PR-MSP leaders hoped that the train-the-trainers activities would serve the additional purpose of preparing university faculty members to improve instruction in the courses they taught to prospective teachers.

Supports for Teacher-Level Change

With a goal of transforming science education at all levels of the system, but a recognition that they did not have the time or resources to address all areas of the science education system in depth, PR-MSP leaders had to decide where to focus their efforts. Past science education reform efforts through the PR-SSI had targeted the development of standards and instructional materials. PR-MSP leaders believed that to bring about real change, they needed to do more than provide teachers with standards, and materials to teach to the standards. They needed to develop teachers’ underlying understanding of science so that they could teach science more effectively to their students.

The centerpiece of the MSP intervention was the professional development offered to all science and mathematics teachers in participating schools. The professional development was designed as year-long courses consisting of six-day summer institutes followed by six all-day follow-up sessions during the school year. All sessions were to be held at regional Resource Centers. Follow-up sessions would be scheduled on Saturdays, with all regions to hold the sessions on the same dates. Holding the workshops on the same day helped PR-MSP schedule train-the-trainer meetings, which were to precede the professional development. Teachers in grades K–3 participated in both science and mathematics professional development, while grades 4–6 teachers attended either science or mathematics professional development.

The premise of the PD program, and indeed all of PR-MSP’s work, was that improving student mathematics and science achievement meant developing deeper, longer-term content understanding. PR-MSP’s professional development was conceived as a means to enable teachers to guide their students to deeper content understanding. This meant that activities were designed as model learning experiences that teachers could adapt and transfer to their classroom. Facilitators were to provide learning experiences that promoted deep conceptual understanding

for teachers, while modeling aspects of effective teaching, i.e. assessment, collaborative learning, inquiry-based learning, problem solving, questioning, and reflection, all in a safe learning environment.

Professional development activities would emphasize science content, with teachers engaging in explorations of content as learners. Each professional development activity was intended to address four characteristics of learners who learn for understanding:⁴

1. Learners construct relations among concepts and ideas.
2. Learners extend and apply their knowledge.
3. Learners justify and explain what they know.
4. Learners make knowledge their own.

The activities implemented with teachers were not necessarily intended for classroom use as presented. Rather, these activities were meant to deepen teachers' understanding of the content, and model instructional and assessment strategies that could aid in teachers' transfer of their emerging knowledge to the classroom. A PR-MSP leader explained:

We are [developing] the teachers so they have deep knowledge of the content. Maybe some of this content is going to be discussed with the students as they are discussing it here, but what we want to know is that the teachers have a deep understanding of the concept, so sometimes we have to go farther than what the students are going to receive.

With a commitment to developing teachers' conceptual understanding, MSP leaders had to decide what science content would be addressed. To ensure support for the professional development, the decisions would be based on a needs assessment conducted with teachers, making sure that whatever content would be addressed would be aligned with PRDE's science standards. At the same time, MSP leaders believed that the choice of content was less important than modeling how to teach for deep conceptual understanding:

We have made very clear that we will not be able to address all the concepts in biotechnology, for example, or movement or magnetism. That is okay because we want to model the way we think it should be done so teachers should be able to make their own activities eventually using the same model and pedagogy...The professional development is really modeling [for] the teachers how you go about deepening the understanding of the students and what it means to really understand conceptually...So for me [the specific concept] doesn't really matter.

Mechanisms were built into PR-MSP to encourage teacher participation, including an agreement with PRDE to give Continuing Education Credit for professional development activities and a provision for the credits to be applied toward moving up the ladder of the Teaching Career Law that provided step increases in salary. Teachers would also receive stipends for attending the professional development.

⁴ Carpenter, T. P., Blanton, M. L., Cobb, P., Franke, M. L., Kaput, J., and McClain, K. (2004). *Scaling up innovative practices in mathematics and science*. Madison, WI: National Center for Improving Student Learning and Achievement in Mathematics and Science, Wisconsin Center for Education Research.

The proposal designated a “support for transfer” phase, in which regional working teams of university science faculty would visit teachers regularly to “follow up on the content knowledge and pedagogy needed to transfer their learned knowledge and skills to classroom practice.” In addition, science lead teachers and Resource Teachers would be available to support teachers on site. The lead teachers at each school were to play a central role on their school’s base teams and in providing support to teachers as they implemented classroom changes.

Supports for School-Level Change

The rationale for developing support at the school level was based on research on effective schools, which suggests that the school should be the fundamental unit of change. PR-MSP planned to devote considerable resources to developing learning communities at the school level. The idea was that these school-based learning communities would help create a school culture focused on student learning, and would support the instruction and assessment practices that teachers learned at the professional development workshops. The rationale for school-based learning communities was spelled out in the PR-MSP proposal:

A reason for choosing [learning communities] is that school culture is a main element for enhancing the transferability of professional development initiatives into active practice classrooms... So it is an essential aspect to consider when planning, delivering and following-up professional development programs...Furthermore, [learning communities] enhance the likelihood that school transformations are institutionalized.

Each learning community would be anchored by a “base team” comprised of a knowledgeable core of teachers and administrators (e.g., principal, lead science teacher, social worker) who understood the goals of PR-MSP and could support teachers as they made changes in the classroom. The capacity of base teams would be developed through “residential” planned and monitored by the Learning Communities Working Team—a group of PR-MSP leaders and liaisons from core partner institutions. As with other Working Teams, the Learning Communities Working Team included representatives from PRDE and each of the core UPR partners.

PR-MSP in Action

Vignette

Early on a Saturday morning, Lisa⁵ unlocks the doors at the local elementary school. Elementary teachers from schools across the region are making their way to the school, and Lisa is preparing for their arrival. She is the Resource Teacher at this school, and today is one of several professional development opportunities offered to teachers throughout the school year. As a Resource Teacher, Lisa coordinates registration for workshops and staffs the Resource Center, a former classroom transformed to house computers with internet access and science instructional materials that can be borrowed for classroom use. In preparation for this work, Lisa, an experienced elementary teacher, has attended professional development opportunities that have increased her understanding of effective professional development focused on teacher content knowledge.

Lisa arrives early to ensure that the materials are ready for the professional development, which will include concurrent sessions focused on deepening teachers' understanding of weather and climate, and controlling variables. She expects a good turnout, roughly 60 teachers, in part because local professional development opportunities for teachers are hard to come by in Puerto Rico. In addition, the Resource Center provides a convenient location for both interested teachers and the facilitators of these offerings, university faculty and retired and current middle and high school science teachers.

After a long day of making sure the facilitators and teachers have what they need, and observing portions of both workshops, Lisa's job is still not done. She stations herself in the Resource Center, ready to assist teachers seeking help in designing science lessons. She knows teachers will be eager to enhance their units on weather and climate after having a chance to learn more about the topic during the workshop.

On Monday, Lisa will return to school, ready to teach her own third graders. At the end of the day, she will open the Resource Center again, providing an hour for teachers in her own school as well as teachers across the region to use the computers, explore the available instructional materials, and ask her for assistance as needed in thinking about and providing effective science instruction.

Developing Support within PRDE: Slow But Sure

Based on what they had learned in the PR-SSI experience, university leaders for PR-MSP were purposeful in engaging PRDE with the work. Throughout the MSP, university PR-MSP leaders met monthly and invited PRDE staff to participate. While PR-MSP was not successful in getting the sub-secretary to the meetings, the science director typically attended and became well-informed about and supportive of PR-MSP. At the regional level, university leaders met with regional directors and superintendents personally and invited them to meetings and other activities geared specifically to their needs. These sessions focused on topics such as strategic planning, school and district professional development planning, formation of school learning communities, data-based decision making, and how to ensure meetings would be productive.

Initially, it was a struggle to fully engage PRDE with the work. PRDE staff tended to view PR-MSP as “just another project.” University leaders persisted in their efforts to keep PRDE at the table, however. PR-MSP leaders noted that over time, Department staff came to believe that the initiative was helping them achieve Department goals; they also came to value PR-MSP's focus on school-level and district-level change, and they wanted the MSP's help in modifying their policies and practices to support this kind of change. A PR-MSP leader remarked:

⁵ Pseudonyms have been used.

At the beginning [PRDE leaders] were very skeptical. [Then] they went to our meetings and they started seeing what we were doing. Very slowly they started liking what we were doing and asking for more information. They started saying that they were going to copy what we were doing.... There are a lot of things that we have started in [the PR-MSP] now that it's a policy of the Department of Education because they have seen that it works.... We started by telling them that we wanted them to participate more and we didn't hear anything. And then, all of a sudden, we have this call: "We want to expand this. We like what you're doing."

Support for PR-MSP was also built at the regional level. Again, there was initially minimal participation from superintendents and directors in PR-MSP activities, but project leaders noted that participation and enthusiasm increased over time. In one region, a superintendent who had initially failed to participate in PR-MSP activities later adopted the learning community concept promoted by PR-MSP, and set out to develop her entire district as a learning community. School principals, too, were reported to be highly supportive of PR-MSP. Said a PR-MSP leader, "Through workshops and residencies, our principals have been very involved in the MSP."

Expanding the Regional Infrastructure: Preparing to Reach Large Numbers of Teachers

The initial MSP proposal called for beginning the work with 146 elementary, middle, and high schools, then doubling the number twice to a total of 584 schools by the end of the MSP. As recognized by the NSF-appointed team that carried out a critical review of the project in its second year, this plan proved to be too ambitious. Following the recommendations of the team, PR-MSP was supporting 155 schools by the final year, instead of the 584 PR-MSP schools envisioned. PR-MSP leaders eventually invited teachers from non-PR-MSP schools to participate, resulting in 400 teachers representing 150 non-PR-MSP schools attending the professional development. A PR-MSP leader explained:

The original plan of our MSP was to reach all schools in Puerto Rico. ... We thought it was very ambitious. We're sure right now it was ambitious. The thing is that we still want to do that. We still think we need to do that... What we do is we envision a way of doing things, but when you actually go and you start doing it, you learn along the way that some things are not working that well and that there are things that can be improved.

Twenty-eight of the 30 Resource Centers the MSP proposal called for were created.⁶ These Resource Centers served the intended function of providing a site and logistical support for professional development, and as a repository of materials and resources for teachers. Most teachers were 45 minutes or less from the nearest Resource Center.

As had been planned, a typical Resource Center might be open for two hours after school and for six hours on Saturdays. Teachers from that particular school were the most frequent visitors to a Center in the after-school time slot, with more participation from across the region on Saturdays. Although the Resource Centers were originally open only to teachers from PR-MSP schools, the Centers were later opened to non-PR-MSP teachers as well. One of the most popular uses of the Centers was to access the Internet.

⁶ Changes in leadership at two sites interfered with PR-MSP plans.

As planned, regional Resource Teachers were selected by the schools, based on PR-MSP criteria which stipulated that the teachers should be active participants in professional development as well as exemplary teachers. For their multiple responsibilities, these Resource Teachers received \$7,200 each year. They were provided with workshops and residentials; “lots of them,” according to one PR-MSP leader. They were also invited to attend all of the professional development offered to other teachers, but the logistics proved difficult because Resource Teachers had to staff Resource Centers while the workshops took place. PR-MSP leaders adapted by designing a special professional development subprogram at the residentials for these teachers which included, for example, experiencing activities that were used in the professional development program. Even so, one Resource Teacher interviewed by the research team reported that she felt well-prepared to help teachers select materials and integrate them into their classes, but less well-prepared in the science concepts. To make up for this, she studied the workshop materials independently and discussed them with the workshop facilitators to make sure she was attuned to teacher needs.

Professional Development Capacity: Training the Trainers

The 30 facilitators who planned and delivered the PR-MSP science courses for elementary teachers included university science and science education professors, and exemplary and retired exemplary secondary science teachers. While teachers were divided into zones for their professional development experiences, facilitators were not; facilitators across all zones trained together for their roles. In the first year of the project, initial training for facilitators included two multi-day workshops (retreats) focusing on the philosophy of PR-MSP, PR-MSP goals and objectives, and the concept of school-based learning communities.

The project immediately recognized that the facilitators needed more support in order to be prepared to work with teachers, so the train-the-trainers program was expanded. During the sessions, facilitators were convened by grade range (K–3, 4–6) to design, write, and/or practice the upcoming workshop for the teachers. In addition, one week prior to each of the six Saturday follow-up sessions, one final coordinating session was held as a dry run of the session that would be provided to K–6 teachers, giving the facilitators a chance to refine the session as needed. This final session included pre-service teachers who would be assisting in the facilitation. The pre-service teachers initially attended to logistical aspects of the workshops; over time their responsibilities expanded to include helping facilitators adapt the workshops to specific teacher groups and working alongside the facilitator to implement the workshop.

In the first year, the professional development for the facilitators was focused largely on developing content-deepening experiences for teachers that would promote deep conceptual understanding, promote inquiry and problem solving, and include multiple opportunities for the facilitators to assess teachers’ learning. In later years, PR-MSP leaders utilized smaller groups of developers—many of whom were university faculty—to develop the professional development. Groups from grades 7–12 were further divided into clusters according to the workshop topic. A university-based content expert worked with each of the groups and clusters. These retreats were less intensive than the early ones, typically occurring twice a year, each time for a single Saturday. University faculty were provided a \$250 honorarium for each professional development activity they designed. The developers then trained the remaining facilitators to use

the professional development materials and elicited their feedback on the materials, subsequently revising them as needed.

Each school year, facilitators received between 32 and 83 contact hours of professional development intended to prepare them for their role. As the cadre of facilitators grew in their capacity to deepen teachers' content knowledge, the train-the-trainers sessions shifted from development of activities to other areas, all the while maintaining a tight focus on teachers' content knowledge and the promotion of student learning. The sessions for the facilitators continued to be grounded in the work they were being prepared to do—providing content-deepening experiences for their teachers. For example, facilitators were challenged to enhance their skills at analyzing student data with teachers. Professional development for the facilitators continued to push them to think about the transfer of teachers' learning to the classroom, which included promoting and monitoring teachers' learning and implementing units of instruction on grade-specific concepts. Facilitators were trained in gathering evidence of transfer to the classroom, observing teachers, and preparing teachers for a culminating showcase in which they presented their implementation of an activity from one of the units, including students' prior knowledge, the learning activity, the assessment and the results of that assessment, and their personal reflection on the lesson.

Facilitators were compensated for their time. University faculty and exemplary teachers received \$450 for each day of professional development they either participated in as “trainers” or delivered to teachers. In addition to facilitating sessions for teachers, facilitators met for about an hour with the resource teachers and the pre-service teachers who assisted in the facilitation immediately following each workshop to reflect on the experience and revise the materials, if needed. A PR-MSP leader spoke of the pivotal role of the professional development facilitators in building the capacity of teachers to teach science concepts:

The whole MSP is in their hands... The philosophy of the MSP depends on them, so we have the highest expectations. They are supposed to promote deep conceptual understanding with the teachers because that is what we want the teachers to do with their students. That is it. I have to be very emphatic, that is our delivery to the teachers, is the [facilitators].

As noted earlier, PR-MSP divided the Island into four zones; each zone included two or three regions and was affiliated with a university in the zone. Zonal support teams were led by a co-principal investigator, and each included a science liaison from the university who oversaw all K–12 science facilitators in the zone, and was responsible for: (1) coordinating the planning of the professional development, including zone-specific modifications to the professional development; (2) coaching the facilitators; and (3) making sure the professional development within that zone was implemented and the facilitators had everything they needed. In addition, each science liaison had an island-wide grade-level specialty: K–3, 4–6, 7–9, or 10–12, resulting in each liaison also having an oversight role in professional development for the assigned grade range. Each liaison was responsible for understanding what was happening at their particular grade range across the island. The science liaisons typically devoted 20–25 hours each month to the work of the MSP, and received \$50 per hour for their efforts.

The professional development appears to have been implemented largely as intended. School-year elementary science workshops that were observed by the research team were aligned with the recommended format, structure, and goals of the training. Facilitators appeared knowledgeable and well-prepared, and teachers were engaged in the work.

Providing Professional Development for Teachers: Getting to the Nitty Gritty

Implementing the plan for teacher professional development first required identifying concepts around which to focus the courses. The initial process for selecting the content to be addressed in the professional development was to conduct a needs assessment in which teachers were asked to identify their science content needs. From this list, PR-MSP leaders selected content reflecting core concepts that aligned with PRDE's science standards.

Some of the content was selected when PR-MSP leaders and facilitators identified a need based on their workshop observations. The selected topics were addressed island-wide, with minor local modifications, if needed, so there continued to be a good deal of consistency across workshops. For example, one of the summer workshops focused on the use of curriculum mapping as a way for them to see how the same concepts are to be discussed at the different grades, after PR-MSP leaders realized that “teachers needed a structure...to help them find the most important concepts that they have to teach the students.” Similarly, follow-up sessions for K-3 teachers one year focused on the scientific process because teachers had requested it, and PR-MSP leaders and facilitators agreed that it was an area of weakness for this group of teachers.

Throughout the five years of PD, the same topics and concepts were addressed in all regions and zones as facilitators and liaisons identified common areas of need at particular grade levels. While the topics were consistent across sites, flexibility was expected in the pacing of the work; facilitators were urged to make sure participants understood the concepts before moving on. PR-MSP emphasized depth of learning, encouraging facilitators to focus on teachers having meaningful learning experiences that would deepen their content knowledge and model effective instruction. Facilitators frequently assessed the teachers' learning, using this feedback to make decisions about whether teachers were ready to proceed to the next concept. The evaluation team also assessed teacher learning and transfer-to-the-classroom through various methods, including tests, alternative assessment techniques, and case studies; evaluators regularly fed back results to professional development leaders so they could fine-tune the program.

University leaders reported that their initial efforts with K-3 teachers were frustrating for facilitators and teachers alike. Facilitators and PR-MSP leaders were concerned that they were “going over the heads” of K-3 teachers, and teachers complained that the student assessment activities were not easily transferable to the classroom due to the amount of writing these tasks necessitated on the part of the students. PR-MSP leaders considered dropping K-3 teachers from the MSP, but then decided to seek input from the teachers themselves. This eventually led PR-MSP to assign science liaisons to specific grades levels (K-3, 4-6, 7-9, 10-12) to ensure that PR-MSP met the needs of teachers at each level—and that teachers at all levels understood PR-MSP's philosophy of deepening teachers' conceptual understanding.

The fact that PR-MSP leaders considered dropping K-3 teachers from the MSP suggests a tension between reaching all teachers of science across the Island and wanting to reach these

teachers in a manner consistent with the PR-MSP philosophy of deepening teacher understanding of science concepts. The reaction of K–3 teachers appeared to have been due to their difficulty in accepting that they had to understand the science concepts in order to teach them to their students. This difficulty was likely the result of a lack of teacher specialization at the K–3 level, as well as teachers having little science background. PR-MSP was convinced that the K–3 level is crucial for developing thinking skills and habits of mind and for understanding basic science concepts, trumping any notions about limiting the PR-MSP’s influence to those whose primary focus was science.

A typical teacher attended 11 days of professional development each year, including a one-week session in the summer and a total of six, one-day Saturday sessions during the school year. Teachers received a \$50 stipend for each session they attended, up to \$550 per year.

Creating a School Culture That Supports Change: Percolating from Within

The Learning Communities Working Team, made up of PR-MSP representatives from core partner institutions, was formed to plan training and activities for school-based learning communities. The Working Team based its work on Peter Senge’s book *Schools That Learn*.⁷ Early in the MSP, Senge’s co-author, Tim Lucas, met with the Working Team and was featured as the keynote speaker for the first workshop for school base teams, each comprising science teachers, mathematics teachers, the principal, and the social worker, or other ancillary staff like the guidance counselor or the librarian. The Working Team met for a retreat the month following this workshop to be trained on how to establish learning communities both within their own institutions and the PR-MSP schools. Residentials were held each year for base teams, covering such topics as learning communities, conflict resolution, team building, and cooperative learning.

While base teams received common training, the implementation of school-based learning communities was left to individual schools, which experienced varying levels of success. Typical challenges included finding time to do their work, managing conflict, and communicating effectively with the broader school community. At one school with a positive experience, the principal and Resource Teacher indicated that the base team consisted of science teachers, mathematics teachers, the social worker, and the principal, but that the entire school participated in the learning community. Both the principal and Resource Teacher indicated that the base team did not hold formal meetings, but provided support to teachers in less formal ways, such as making sure they had the materials they needed following professional development. In addition, the school released students early one day per month to hold grade-level team meetings. At some of these meetings, teachers participated in activities around the PR-MSP materials.

While initial PR-MSP plans called for providing teachers with classroom support through Resource Centers, visitations by PR-MSP staff, and school-based lead teachers, only Resource Center support developed as intended. Regional Resource Teachers provided support by helping teachers find materials and resources, but they were not involved in supporting classroom implementation directly.

⁷ Senge, P., Cambron-McCabe, N., Lucas, T., Smith, B., Dutton, J., & Kleiner, A. (2000). *Schools that learn: A fifth discipline fieldbook for educators, parents, and everyone who cares about education*. New York: Doubleday/Currency.

Facilitators who were classroom teachers could not conduct any classroom observations because of a lack of release time from their own classrooms; university faculty did the observations. Classroom visits by university faculty did not begin until the final year of the MSP. PR-MSP leaders had found that developing, preparing for, and delivering the professional development consumed an enormous amount of time and energy, leaving little time for classroom support until very late in the MSP grant period.

Another form of support proposed in early PR-MSP documents was to have science lead teachers at each school support teachers in implementation. The plan was for lead teachers to organize and facilitate their schools' learning communities, and to provide peer coaching to their colleagues as a way to support their implementation of curricular changes. In reality, lead teachers did not play a central role in providing school-level support. Typically, science lead teachers reminded teachers about upcoming professional development and supported the Resource Teachers in their preparations for the professional development. However, in the last year there was evidence that lead teachers were trying to provide classroom support. Each lead teacher selected one or two teachers to peer coach, although these coaching experiences were challenging and limited in their reach. The challenges were in part due to school cultures in which teachers kept their classroom practice private, making discussions of teaching practice between the lead teacher and the classroom teacher difficult. In addition, finding time for the lead teacher and classroom teacher to meet constrained the extent to which the peer coaching could be implemented.

Facilitating Opportunities to Study Issues of Practice: Pursuing Interests

PR-MSP leaders developed a new strategy, communities of practice, in response to a need expressed during the initiative's first year. This strategy initially emerged as a response to K-3 teachers' unmet needs that, as noted earlier, were probed when PR-MSP leaders decided to seek input from these teachers with the purpose of understanding their particular needs. Communities of practice were essentially study groups of a limited duration, formed by small groups of teachers willing to explore a particular practice or issue in greater depth than they were able to do during the regular professional development. Several such study groups were created during PR-MSP, including an island-wide K-3 group that formed around the topic of assessments and rubrics to evaluate content learning. This group set its own agenda, met regularly during the semester, and participated in an intensive, two-day workshop in the summer. About 25 teachers participated (from across zones), along with two facilitators. Communities of practice were also created to learn about classroom action research and use it to tackle student problems related to learning with understanding. In all cases, understanding science content was the focus of these groups.

The communities of practice were intensive experiences in which teachers received support from university faculty to devise teaching and assessment strategies to address problems related to student learning of science content. The experience of participating in a community of practice was also extensive. For example, the groups focused on action research met for a minimum of 40 hours during the school year (10 four-hour sessions), with additional time devoted to creating and delivering a presentation in an annual PR-MSP research congress. Out of 19 of these presentations, seven were carried out by elementary science teachers. Action research projects

presented by K-3 teachers focused on learning topics such as insects and spiders, the re-use and separation of recyclable materials, and the concept of light; while the presentations of 4-6 teachers focused on concepts like mitosis, heterogeneous and homogeneous mixtures and mixture separation.

Key Factors in the Implementation of PR-MSP

Puerto Rico's experience with the MSP grant was successful in many respects. Much of the success can be attributed to the groundwork that was laid and the lessons that were learned by university MSP leaders in various prior NSF grants. For example, the PR-SSI paved the way for PR-MSP by establishing partnerships among universities and between the K-12 system and the higher education system. At the same time, PR-MSP leaders recognized that key components of the PR-SSI might have been more sustainable had university partners worked more closely with PRDE. Based on this experience, PR-MSP incorporated the most successful components of PR-SSI, but focused more energy on making the work a true partnership between the university system and PRDE and on the end product: student learning. Securing stakeholder support long-term would allow PR-MSP leaders to develop both infrastructure and capacity that could serve as a foundation for future work as resources become available. The factors that seemed key in the PR-MSP experience are identified below.

- Keeping a focus on maintaining PRDE involvement contributed to the buy-in of K-12 educators and policymakers, and helped institutionalize a partnership between universities and the K-12 system.
- PR-MSP increased the capacity of university faculty and exemplary teachers to deepen teachers' conceptual understanding of science to promote student learning.
- The establishment of regional Resource Centers provided a venue for ongoing efforts to deepen teacher content knowledge.
- School-based learning communities provided support to teachers in their efforts to change their instruction to promote student learning.

Keeping a focus on maintaining PRDE involvement contributed to the buy-in of K-12 educators and policymakers, and helped institutionalize a partnership between universities and the K-12 system.

PR-MSP included representatives from each of the core partners, including PRDE, on its leadership teams and on each of the Working Teams that designed, oversaw, and recommended courses of action for the project's individual components. These structures ensured that PRDE had ongoing involvement in the project's plans and the implementation of those plans.

PR-MSP gave increasing attention to building support at the regional level by creating professional development for regional superintendents and encouraging them to attend professional development for school-based staff. In addition, the zonal support teams expanded over the course of the project to include regional directors, superintendents, and mathematics supervisors, school directors, and the PR-MSP resource teachers. The expansion had a two-fold purpose: to focus on the needs of all of the schools in the zone and cultivate long-lasting working

relationships among PRDE, PRDE schools, and university faculty.⁸ University faculty, as well as PRDE staff at the central, regional, and school levels, indicated that they had been energized and gratified by the partnership, and hoped the work would continue. The result was that as MSP funding ended, PRDE developed plans to continue some of the work that PR-MSP had started. There was also a sense among PR-MSP leaders that PRDE had come to expect MSPs to have more of a focus on academic achievement (rather than student behavior) as a result of their participation in PR-MSP.

The fact that PR-MSP aligned well with the needs of the system was instrumental in garnering PRDE staff support. The PR-MSP was funded at a time when PRDE lacked resources in the area of science; there were no science supervisors in place, and PRDE offered virtually no science professional development. Thus, PR-MSP filled a void that the Department did not, at the time, have the capacity to fill. In addition, the developers of PR-MSP's professional development and materials made sure that they were aligned with Puerto Rico's science standards, thus increasing the appeal for PRDE staff and teachers.

PR-MSP was also aligned with the needs of teachers. The MSP proposal noted that many science teachers across the island did not have proper credentials, and that most teachers had no experience in scientific research to teach students the content, nature, and processes of science. The PR-MSP focus on deepening teachers' understanding of key science concepts, then, aligned well with the perceived needs of teachers within the PRDE system.

PR-MSP leaders were also responsive to teachers' expressed needs throughout the life of the MSP. Initially, a needs assessment was conducted to obtain teacher input into the content that should be covered in the professional development. As the professional development was implemented, facilitators adapted the pacing and, to an extent, the content to meet the needs expressed by teachers and identified by facilitators. Early on, there was some uncertainty about whether PR-MSP, with its heavy focus on science content knowledge, could meet the needs of K-3 teachers. PR-MSP leaders worked with this group of teachers to ensure that those teachers' needs were met while also staying true to the MSP's commitment to deepen teacher content knowledge.

PR-MSP increased the capacity of university faculty and exemplary teachers to deepen teachers' conceptual understanding of science to promote student learning.

Past efforts to improve science education in Puerto Rico had focused primarily on standards and instructional materials. In contrast, PR-MSP was focused on developing teachers' understanding of important science concepts. This focus for science professional development may have set the stage for future work on a number of levels. First, the emphasis on science content knowledge provided a natural focus and common goal to the partnership between PRDE (at its many levels) and university science faculty. Capacity was developed among a large number of university faculty and exemplary teachers to offer intensive science professional development to teachers. The hope was that the hundreds of teachers who participated in the professional development would also serve as resources to other science teachers.

⁸ Arce, J., Bravo, M., Fortis, M., Del Llano, A., and Wayland, K. (Eds.). (2010). *Sharing our journey to improve mathematics and science education*. Retrieved from <http://www.uprrp.edu/alacima>

Capacity was also built among university faculty to improve their own college-level instruction as a result of their work with teachers through PR-MSP—improvements that would affect future teachers, among others. As one PR-MSP leader remarked:

The people who have gained more than anyone else are the [facilitators]... They have learned new strategies to teach in a better, more interesting way. They have learned to understand those students; they have learned to be more capable of doing assessment of the classroom, hands-on activities. I have people who said, “Gosh, I have changed completely the way I teach.”

The establishment of regional Resource Centers provided a venue for ongoing efforts to deepen teacher content knowledge.

The most tangible evidence of PR-MSP’s sustained impact is the system of Resource Centers, which PRDE hopes to maintain after MSP funding ends. The infrastructure created to support the Resource Centers and professional development was effective in reaching and supporting schools and teachers throughout Puerto Rico. Each University of Puerto Rico site acted as a zone serving designated regions. Each of the zones had a science liaison who supported the science professional development for teachers in grades K–12 in his/her regions. Each liaison also had an island-wide grade range specialty: K–3, 4–6, 7–9, or 10–12, meaning that each liaison was in charge of the group of facilitators who provided professional development for the assigned grade range across the island. In addition, a PR-MSP manager in each zone stayed in touch with schools to make sure the MSP was running smoothly. A regional Resource Teacher commented:

We have had a lot of support from our manager... Every region has [a PR-MSP] manager. [Our manager] is always calling and asking how everything is, “Do teachers need anything special? Is there anything you don’t have in the center that teachers asked you for?” She is always there.

School-based learning communities provided support to teachers in their efforts to change their instruction to promote student learning.

The school-based learning community concept was the key vehicle within PR-MSP for ensuring cultural change at the school level to support new kinds of science instruction. PR-MSP leaders and documents described school-based learning communities as central to ensuring sustainability at the school level. One PR-MSP leader spoke of the importance of school-based learning communities to sustaining the work:

The most difficult part to maintain is the [school-based] learning communities component. It is very important. It is an MSP about content. It’s about science and math, but it’s really about changing human beings’ attitudes, motivation, understanding; to keep working with people. It’s not working with content, it’s working with people. So the learning communities component has done a lot and we’ve put a lot of effort toward modifying attitudes toward what it means to be in a classroom, what it means to teach, and what it means to learn.

Likelihood of Lasting Impact

Through prior NSF grants, partnerships had been developed among universities on the Island, as well as between universities and the K–12 system. PR-MSP university leaders planned for sustainability of certain aspects of the work from the beginning, based on lessons learned from the PR-SSI. PR-MSP leaders and participants described their hopes for the work beyond the funding period; their views, as well as initial evidence of what is likely to be sustained, are shared in the following sections.

The Partnership

As noted earlier, central to the PR-MSP's plan was full engagement of PRDE to ensure that they would carry on the work after MSP funding ended. University leaders of PR-MSP included PRDE as a full partner in the work from the time they wrote the proposal. They did not just “write them in” to the proposal and obtain their endorsement, but made sure key PRDE leaders were present at important planning meetings. The PR-MSP proposal acknowledged that simply writing the Department of Education into the MSP “does not lead to full institutionalization after external-funded MSPs end.” A PR-MSP leader remarked:

When we started there was a lot of skepticism because the Puerto Rico SSI did a lot of the things...then all of a sudden there were no funds and the Department of Education let it go, so teachers were concerned. They were not against us, but they kept asking if this is going to be the same thing. “Are we going to start something and then there is not going to be any sustainability?”

The following remarks of these PR-MSP leaders, after being immersed in the work for nearly four years, illustrate their optimism about the sustainability of the partnership:

For me, this is the closest I have been to the Department of Education. Even though SSI was working with the Department of Education, I didn't even meet the people from the Department of Education. Now I have contact. I know them and they know me, and they know if they need something with science content, they can call me. I think that is very important.

We have been able to break down the barriers between the university and the schools. Usually most of these MSPs where professors are involved, professors see themselves as holier-than-thou and the holders of the truth and knowledge. We have been successful in showing us as colleagues of the teachers, not as people who are better...And also, the fact that we have taken professional development out of the university and into the classroom. In too many of the MSPs, teachers come to the universities to have the workshop. In this case, through the Resource Centers, they are in their own environment, and that is an accomplishment of [the PR-MSP].

As the MSP funding period was winding down, a plan was under development to seek external funding to maintain the PR-MSP Center at Rio Piedras to oversee the on-going work, and the sustainability of the partnership between K–12 and higher education may well depend on whether PR-MSP leaders are successful in those efforts. While networks have been formed and

there is clearly a desire to continue working together, it may be difficult for either partner to make the work a priority unless there are staff who have dedicated time to address this goal.

Professional Development and Resource Centers

PR-MSP funded a total of only 10 Resource Centers in 2009-10 with unobligated NSF funds for three years. This is a subset of the original 29 that included 10 elementary, 10 intermediate, and 9 high school centers. The operating hours of the Resource Centers were reduced from 20 hours per week to 10, but the Centers were still staffed by Resource Teachers. These resource teachers annually participated in three training sessions and received a \$2,000 stipend for their time and effort in running the Centers and maintaining the professional development program for their peers in the topics covered in their training sessions.

University leaders and PRDE staff developed a plan of action both to continue the existing Resource Centers and to eventually expand to develop more Resource Centers. Schools could apply to PRDE for these funds. Resource Teachers in existing centers had received training from PR-MSP staff on how to write grant proposals to maintain their centers. Four Resource Centers submitted proposals, but with the election of a new Secretary of Education in the Commonwealth, the future of these proposals was unclear.

In the end, the plan called for pairing 15 new centers with 15 existing centers, and adding 15 new centers each year for a three-year period, for a total of 45 new Resource Centers, with particular focus on the elementary grades. PRDE intended to use federal funding to support the centers. In December 2008, PRDE approved the first phase of *AIA CiMa²: Science and Mathematics Centers of Excellence*. This phase included the creation of 15 new elementary resource centers to support 112 schools (selected by the PRDE), professional development for their mathematics and science Resource Teachers, and the beginning of professional development for the mathematics and science teachers in those schools (approximately 1350 teachers). PRDE also planned to use two of the original PR-MSP intermediate Resource Centers to fill the needs of some of these intermediate schools. That first phase successfully finished on December 2009. PR-MSP submitted a second proposal and the second phase of *Science and Mathematics Centers of Excellence* began in June 2010. In this second phase the teachers from the 112 schools will continue with their professional development program until September 2011. PR-MSP leaders will seek out funding to continue this work beyond September 2011.

One element of PR-MSP that is likely to be sustained and available to additional teachers is a repository of all the materials that have been developed by PR-MSP. These materials are currently available on the PR-MSP website (see www.prmisp.net) that will eventually be shared with PRDE for posting on its website.

Regardless of whether these Resource Centers will be maintained, PR-MSP created a sizeable cadre of university faculty and teachers who have the knowledge to improve science instruction by offering professional development that deepens teachers' understanding of key science concepts.

Improved Science Instruction

PR-MSP offered intensive professional development to hundreds of teachers across Puerto Rico. In 2006–07, for example, approximately 1,600 K–12 mathematics and science teachers participated in summer institutes, and more than 2,500 teachers participated in school-year sessions. PR-MSP’s approach to deepening teachers’ content knowledge was to build teacher capacity by modeling how to deepen conceptual understanding so that teachers could continue to expand their understandings and skills after MSP funding ended.

Many PR-MSP participants believed that even if nothing else remained from PR-MSP, at least the teachers who participated would continue teaching in the ways they had learned through PR-MSP. One teacher remarked, “The gain is inside the individual.” A PR-MSP leader concurred:

The way of teaching has changed for most of these teachers, their teaching practices; the fact that we have encouraged them to use low-cost equipment and materials in many of the activities also. You don’t need fancy equipment to do the experiments. I know that some of the Resource Centers have by themselves established networks with other schools that they serve. This is already happening. They’re doing activities themselves, not directed by us. So I think that’s going to keep happening also.

A representative of PRDE also indicated a belief that changes in teacher practice would be sustained beyond MSP funding:

Through [PR-MSP’s] work, the teachers are now empowered with an improved knowledge base, which will enable them to transfer what they know to their students, helping them to be successful learners.

Learning Communities

In spite of PR-MSP’s commitment to learning communities, and the substantial amount of resources devoted to their development, PR-MSP leaders feared that learning communities would be difficult to sustain without continued funding. Results of school culture surveys administered to K–12 teachers, principals, and ancillary staff (e.g., guidance counselors) two times during the course of the project revealed that there was still much work to be done. Base teams reported ongoing challenges in building learning communities, and case studies revealed that at least some teachers were concerned about the adequacy of support from peers, and in some cases from the base teams themselves.

One principal interviewed by the research team for this report had modified the school schedule to provide early release to students once a month so that teachers could work and plan together. This principal pledged to maintain the learning community at her school. At the same time, she was concerned that if she were to leave the school, the learning community would be difficult to maintain without training from PR-MSP for a new administrator.

Some other individuals were more optimistic that the learning community concept had been internalized. One regional superintendent hoped to implement learning communities in her

district, and the new Secretary of Education was reportedly interested in the learning communities concept. Said one PR-MSP leader:

I hope that the bonds are so strong now within the school that they don't just think of themselves as the [PR-MSP] people, but that there is this group of people that now think differently and teach differently, that they will keep doing it. I hope that what stays is a way of doing things, a culture; that we have been able to change the culture.

Closing Thoughts

Over the last 15 years, a great deal of work has been done in Puerto Rico to upgrade the knowledge and skills of science teachers so that students can meet challenging science standards. University leaders of this work have dedicated themselves to the long-term goal of offering a challenging science program to *all* public school students across the island. With each attempt, MSP leaders have learned more about what works and what does not, and have built on lessons learned to refine their approaches. By fully engaging PRDE and the university system in the work of science education reform during the PR-MSP, reform leaders built synergy, momentum, and commitment that promise to support ongoing improvements in science education.