INVERNESS RESEARCH

Teachers As Science Champions

The Legacy of 15 Years of NSF Investment in Science Education Improvement

A Retrospective Study of Bay Area Schools for Excellence in Education (BASEE), Partnership for Student Success in Science (PS^3), and Noyce Master Teacher Program (NMTP)

by Barbara Heenan and Jenifer V. Helms

October 2013

A summary version of this report is also available online from Inverness Research by clicking the link here.

Contents

Inverness Research, a national education evaluation and consulting group headquartered in Northern California, has over 30 years of experience studying local, state, and national investments in the improvement of education.

Inverness Research * P.O. Box 313, Inverness, CA 94937 * Ph: 415-669-7156 * Fax: 415-669-7186
www.inverness-research.org

EXECUTIVE SUMMARY

We at Inverness Research have conducted a "legacy study" focusing on a series of philanthropic investments aimed at improving science education in the San Francisco South Bay Area that extended for over 15 years. Roughly nine school districts enjoyed a steady stream of support for science education improvement that began with funding from the Hewlett-Packard Foundation for the *K-6 Hands-On Science Program* in the early 1990s; launched a more comprehensive endeavor with *Bay Area Schools for Excellence in Education* (BASEE), a National Science Foundation (NSF) Local Systemic Change (LSC) grant in 1997; extended into the *Partnership for Student Success in Science* (PS^3), a NSF Math Science Partnership (MSP) grant funded from 2003-2008; and finally ended with the *Noyce Master Teacher Program* (NMTP), a NSF Noyce grant funded from 2008-2013.

The broad goal of the study was to assess, understand and portray the lasting benefits of an unusually long-term, sustained funding effort in science education. A retrospective study is a rare opportunity to explore the residuals, or enduring benefits, of grants made in science improvement.

Two major questions framed this legacy study:

1. What residual effects and capacities remain years after the completion of these grants?
2. What are the implications of our findings for funders?

We began the study in January 2013 and concluded in October 2013, three months after the last of the grants had expired and over 20 years after the initial grant began. Our research activities included reviewing pertinent background material on the projects; conducting interviews with project leaders; conducting interviews with 21 teachers and nine district and school administrators from districts that had been or still were involved in BASEE, PS^3 and/or NMTP; and, analyzing transcripts to identify key themes and issues.

Our Findings

1. A convergence of contextual factors severely diminished the long-term residuals of what BASEE, PS^3 and NMTP achieved.

In 2008 as the PS^3 came to an end and as the NMTP got underway, in spite of the many successes of the BASEE/PS^3/NMTP efforts, powerful contextual factors converged to wipe out or severely damage much of the important infrastructure and supports for science education that the programs had steadily developed in the previous decade.

- First and foremost, the nation as a whole faced a full-scale recession. The South Bay Area, especially Silicon Valley, was very hard hit, and as a result, school districts were faced with large budget deficits, often forced to slash their services.
- Simultaneously, federal education policy through the No Child Left Behind (NCLB) legislation drove increasing focus on state level academic testing through the California Standards Tests (CST), and reporting through the Standards Testing and Reporting (STAR). Coupled with various "accountability" policies such as the threat of a Program Improvement (PI) designation for failing test scores, schools and districts felt tremendous pressure to

concentrate exclusively on the teaching of basic skills, reading and math. Science, along with other "elective" subjects, was neglected, and in some cases at the elementary level disappeared altogether.

- Churn in policies and priorities disrupted districts' sustained focus on maintaining and strengthening science education programs. Frequent changes in district-level leadership left the efforts adrift. Many of the administrators who had been key supporters of the BASEE/PS^3 initiatives either retired or moved away to other positions as budgets tightened and conditions worsened.

2. There are assets that remain.

Notwithstanding the unanimous agreement among teachers and administrators we interviewed that the once robust and multi-dimensional science programs their districts had boasted during the lifetimes of BASEE/PS^3/NMTP no longer existed, they pointed to some important residual assets established during those years:

- In most of the districts, the science kits and materials are still in place and are being used by elementary teachers.
- In many of the districts, some system for maintaining and refurbishing the kits and materials still exists.
- A tradition of using science kits as well as a heightened propensity to teach science exists in elementary schools in many of the districts.
- Many teachers who were involved in BASEE/PS^3/NMTP are still teaching. Having benefited from past but nevertheless intensive professional development, as well as many accumulated years of good science teaching in their classrooms, their capacity is high.
- In addition, a pool of latent, currently untapped teacher leaders for science education that was deliberately developed by the projects still exists in the districts. Individually, but often alone, they continue on as science champions, advocating and promoting science, as well as sharing their knowledge and expertise in their local venues.
- Relationships and cooperation among the districts that had previously collaborated extensively remain, though to a lesser degree.

3. There is a resurgence of interest in science education.

These remaining assets offer still-extant capacity established through the long-term funding afforded by BASEE/PS^3/NMTP. They are assets that could be tapped today in service of what is a current resurgence of interest in K-8 science education. A renewed attentiveness to science education is fueled by the following converging factors:

- Current efforts by districts to boost attention to science and thereby remedy the inequities among schools that grew out of decades-long federal and state imperatives that focused exclusively on students' math and reading scores and left many schools (especially those serving poor and minority students) forsaking the teaching of science and other "non-essential" subjects

- The emergence of the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS), encouraging districts to turn their attention back to science in an effort to teach higher-level cognitive skills and processes
- California's improving education finances
- Districts' realization that sound fiscal strategy could include viewing the many thousands of dollars invested in science education in the past as having generated assets that could be employed today
- The presence of several new large STEM improvement efforts underway in the Bay Area that are "keeping the flame alive" by maintaining interest in and support for science, and in which some of the BASEE/PS^3/NMTP districts and teachers already participate.

Our Recommendations to Funders

In the immediate future, with the uptick in both the economy and the policy environment, as well as with the appearance of the CCSS and NGSS to which districts are responding, the implication for funders (especially local funders) is to invest now. Funders can take advantage of the affordances that result from the still viable assets accrued in the Bay Area as a result of the many years of previous investments. External funding for local improvement can make a huge difference when conditions are favorable as they are currently.

From a longer-term perspective, this case study shows that it is not reasonable for funders to expect that their temporary infusion of dollars into turbulent systems will create "permanent fixes" or long lasting institutional change. The systems are too unstable and the churn of federal and state policies too great to allow for institutionalizing or even sustaining support for programs put in place by external funding. Hence, we think that funders should focus on the following three ideas:

1. Consider a policy that moves toward making steady, and perhaps smaller, investments over the long-term, not in 2- or 3-year increments. Spanning 15 years, the BASEE/PS^3/NMTP steady stream of funding for science education improvement is a vivid example that shows how continuous support can reap very strong benefits. And these benefits include, most significantly, the development of champions with expertise and commitment—the human capital necessary for achieving sufficient strength and durability to weather lean and unpropitious times.
2. Funding can be most effective when focused on creating supportive, albeit temporary, environments for local educational improvement efforts. These efforts not only create program improvements but also generate leaders or champions who work in systems that will always be in flux. When supportive state, district, and/or school environments arise, they are present, ready and able to take advantage of these more propitious conditions and to work effectively for the improvement of science education in their local settings.
3. Finally, aiming funding toward creating the capacity for ongoing improvements in instruction, largely through the development of teacher leaders and the networks that can connect them, actually does result in an *ongoing process* of local improvement. BASEE, PS^3 and NMTP serve as proof positive of this assertion, showing us how new visions of science education, and "best practices" can only ultimately reside within individuals. They, not the programs, are the heart of the sustainability of our investments.

INTRODUCTION

This Study

The challenge of sustaining education improvement efforts is both fundamental and perennial. Funders who give money, program designers who give creative energy, as well as classroom teachers who give time and attention to implementing innovation are all vitally interested in how to maximize the long-term benefits of their efforts. Their aim is to secure and maintain the gains and accomplishments of their invested time, money and resources.

We at Inverness Research have conducted a "legacy study" focusing on a series of investments in science education in the San Francisco South Bay Area that extended for more than 15 years. Roughly nine school districts enjoyed a steady stream of support for science education improvement. The effort built upon the foundations of original funding from the Hewlett-Packard Foundation for the *K-6 Hands-On Science Program* in the early 1990s; then launched a more comprehensive endeavor with *Bay Area Schools for Excellence in Education* (BASEE), a National Science Foundation (NSF) Local Systemic Change (LSC) grant in 1997; extended into the *Partnership for Student Success in Science* (PS^3), a NSF Math Science Partnership (MSP) grant funded from 2003-2008; and finally ended with the *Noyce Master Teacher Program* (NMTP), a NSF Noyce grant funded from 2008-2013.

Conducted five years after the end of the MSP grant and in the concluding months of the Noyce grant, the study's emphasis was on PS^3 and NMTP, though it was impossible to ignore the influence of their important antecedent, BASEE. Our broadest goal was to assess, understand and portray the lasting benefits of an unusually long-term, sustained funding effort that included all three.

Our Perspective

Educational evaluators, like Inverness Research, usually study programs as they happen, "in real time," offering formative feedback and summative assessment as projects unfold. A retrospective study is a rare opportunity to explore the residuals, or enduring benefits, of a program. It is even more rare to study the effects of continuous funding in a single targeted region.[1]

We at Inverness Research conceptualize education improvement projects as investments. We study the ways in which funders' monies produce immediate outcomes as well as generate continuing returns. Investments in educational improvement might produce short-term results, but those are often not the most important, long lasting, or procreant. Rather, we see that a prime

[1] Inverness Research has conducted other legacy studies of long-term investment in program or system improvement, including the Urban Systemic Initiative funded by the National Science Foundation ("A Study of the National Science Foundation's Urban Systemic Program (USP) Initiative: Understanding the Nature of District Capacity-Building for Mathematics and Science Education Improvement," unpublished paper). Other studies outside of Inverness Research include the Horizon Research, Inc. study of the Local Systemic Change Initiative (http://www.pdmathsci.net/reports/capstone.pdf)

benefit of investment can be the generation of "educational improvement capital." By educational improvement capital we mean working assets that multiple actors in the system can draw upon to fuel future work and to build ever-growing capacity for continuous improvement.

We believe that an examination of the legacy of efforts through the lens of seeing "improvement capital" as a desired outcome of educational investment can yield important lessons, in this case represented by BASEE, PS3 and NMTP. These lessons can be of value to a wide audience, especially to funders who hope to understand more fully the nature of the returns on their investments in science education improvement.

Questions that Framed this Legacy Study

The questions that guided our study and undergird this report are:

- What are the legacies of the BASEE, PS^3 and NMTP efforts?
- What residual effects and capacities remain?
- What factors influenced what remained and what was lost?
- Are there any obvious "assets" or affordances for science improvement that still exist?
- What lessons can be learned about investing in various dimensions of change?
- When investments are made in both systems and individual change, how do they interact and fare over time?
- What are the "take home messages" for funders from this legacy study?

Our Methodology

We began this legacy study in January 2013 by reviewing pertinent background material on both PS^3 and NMTP, and by conducting several iteratively building interviews with the project leaders: Jan Hustler, Director and Co-PI of BASEE, PS^3 and NMTP; Nancy Thomas, Co-PI of BASEE, PS^3 and NMTP; and Kurt McMullin, PI of PS^3 and NMTP.

The bulk of data for this retrospective study came from a series of interviews we conducted with former participants in the projects.

In May 2013 we interviewed 21 teachers, representing eight districts. Each in-depth interview lasted approximately an hour and a half. We asked teachers about 1) their current position and professional background, 2) their past history and current status with BASEE/ PS3/NMTP, 3) their retrospective assessment of BASEE/PS^3/NMTP and its influence, 4) BASEE/ PS3/NMTP influence on their classroom practice, 5) BASEE/ PS3/NMTP influence on their professional vision and thinking, 6) their leadership activities under the aegis of BASEE/ PS3/NMTP, 7) the range of influences on their leadership and their relative importance, and 8) their assessment of the impact and longevity

of their contributions to school, district, etc. We then analyzed the transcripts of these interviews, looking for common themes and patterns in what the interviewees told us.

Later, in August and September 2013, we interviewed three district level administrators and six principals, representing six districts that had been or still were involved in BASEE, PS^3 and/or NMTP. Four of the nine were retired; five were still working, though not all were in the districts where they had originally been involved with PS^3 and NMTP. We asked about 1) their current position and professional background, 2) their past history and current status with BASEE/ PS3/NMTP, 3) their retrospective assessment of BASEE/ PS3/NMTP and its influence, 4) history and current status of the district science program with which they were/had been affiliated, 5) their perspectives on influences of teacher leadership on science and district support for teacher leadership, and 6) contextual conditions that enhance or diminish a district's ability to strengthen science programs. As we did with the teacher interviews, we analyzed transcripts, looking for commonalities among them with an eye for identifying key themes.

We shared preliminary findings from both the teacher interviews and the district/principal interviews with the project leaders, adding their questions, corroborations and insights into the bigger picture of our emerging understandings about the legacies of the investments in PS^3 and NMTP.

I. A DESCRIPTION OF THE NSF INVESTMENTS

BASEE

Funded through a NSF Local Systemic Change (LSC) grant, *Bay Area Schools for Excellence in Education* (BASEE) was an eight-district collaborative working with Hewlett-Packard Foundation to improve science instruction for elementary students. The project vision was to provide science content training and modeling of exemplary pedagogy for approximately 2,000 K-6 teachers. Each of the districts had participated in Hewlett-Packard's *K-6 Hands-On Science Program*, which included training at the National Science Resources Center (NSRC) in Washington, DC, and a three-year $90,000 grant. Each district had a successful initial curriculum launch. The BASEE project aimed to sustain and expand those initial efforts by providing teachers with intensive professional development via both inquiry institutes led by science educators from San Francisco's Exploratorium and content summer institutes led by a triad (scientist + higher education instructor + science resource teacher) instructional team. In addition, a cadre of specially designated and trained Science Resource Teachers (SRTs) provided professional support and coaching at school sites.

PS^3

Partnership for Student Success in Science (PS^3), a NSF Mathematics and Science Partnership (MSP), completed its final year of a 5-year award in August 2008. PS^3 was a partnership of nine school districts in the Silicon Valley, San Jose State University engineers, and businesses that attempted to address middle school student science achievement in the nine districts and elementary student achievement in two of the districts. The school districts range from affluent communities with high-performing schools to less affluent communities with low-achieving schools. The theory of action was predominantly based on a previous NSF Local Systemic Change project (BASEE) that was successful in providing professional development experiences for elementary teachers that supported both content enhancement and pedagogical strategies to implement a kit-based science program in elementary schools. PS^3 offered three important structures for teachers to enhance both their science content and pedagogical knowledge: Summer Institutes, Professional Development Days and Study Groups. As with BASEE, classroom teachers were supported by SRTs who offered on-site professional development.

NMTP

The *Noyce Master Teacher Program* (NMTP) was funded by a combination of two supplemental grants from the NSF for the PS^3 MSP. Twenty-four "master teachers" were recruited from former PS^3 districts. They were specifically chosen based on their experience in high-needs schools, defined as schools with at least 40% of students eligible for free or reduced lunch support. In addition, selection was based on teachers' pedagogical skills and their knowledge of science content.

The three-year long NMTP included three main components. Teachers received continuing content professional development by actively participating in The NSTA (National Science Teachers

Association) Learning Center online—they were required to complete two SciPacks of their choosing each year. The second component consisted of self-reflection papers written by the teachers annually to describe the benefits received from the online professional development and to document changes in their teaching practice. The third component was the requirement that NMTP teachers remain teaching at a school with a high-needs student population for the duration of their participation. Teachers were compensated with generous annual stipends intended to balance the discrepancies in salaries paid by low-SES high-needs districts and high-SES low-needs districts.

Table of Projects and Participating Districts

District	**BASEE** 1998-2003	**PS^3** 2003-2008	**NMTP** 2008-2013
Cupertino Union School District	X	X	
Los Altos School District	X	X	
Menlo Park School District	X	X	
Mountain View-Whisman School District	X	X	X
Palo Alto Unified School District	X	X	
Redwood City School District	X	X	X
Santa Clara Unified School District	X	X	X
Newark Unified School District		X	X
San Mateo–Foster City School District		X	

II. THE DISTRICTS

The Strengths and Benefits of BASEE/PS^3/NMTP from the District Perspective

End-of-project summative reports researched and written by independent evaluators describe the known positive outcomes of BASEE, PS^3 and NMTP. The benefits of these efforts are well established and well documented. We know the projects achieved a range of accomplishments in professional development, curriculum implementation, community support, and student achievement. The question of concern for this legacy study was not whether benefits were ever achieved, but rather, whether or not they still existed in the districts in which they had occurred. What was their "staying power"? What was the residual presence of these achievements today, and had they in fact become what we call "educational improvement capital"?

The district and school administrators we spoke with had very high praise for the design and content of the BASEE/PS^3/NMTP work in their districts. Their retrospective assessments mirrored what evaluation reports described, converging on a dozen positive attributes that stood out for them:

- **BASEE and PS^3 were systemic change efforts deliberately designed to address multiple levels of the system**, which administrators agreed was critical for district level support for

science education improvement. A former Director of Elementary Education in one of the BASEE/PS^3 districts explained what others echoed, "What so impressed me about BASEE was that it employed the structure of systemic change ... there was work with teachers directly, but also work with administrators ... and materials ... and outside resources."[2]

- School and district administrators almost all mentioned the projects' **strong attempts to include district level participation to ensure district buy-in**. District level people were actively involved. One former district administrator explained, "I was part of an administrative team then. We were really consulted, and we were interactive ... we were included in thinking about decisions and about big issues, like sustainability."
- **BASEE and PS^3 included specially designed professional development for school principals**, intended to give them learning experiences similar to those their teachers were having so that they might understand and support the innovations that were underway.
- As a result of the deliberate emphasis on including school and district administrators in the programs, **BASEE and PS^3 increased the overall capacity among instructional leaders to advocate for science**. An Assistant Superintendent described what others also told us: "Somewhere along the way in BASEE and PS^3 a fire was lit under these teachers about their own professional development in that they have demanded it be sustained ... they have been the drivers of their own learning."
- BASEE and PS^3 focused on elementary and then, later, middle school science kits. The **projects made Full Option Science System (FOSS) kits readily available to all and central to the science program** teachers were asked to teach. A principal, who first became familiar with PS^3 as an elementary teacher, explained, "I had never been given instruction, direction or experiences in using hands-on science kits with kids until we started using the FOSS kits ... it completely changed the way I taught science and the way I focused on teaching science."
- **All the districts involved with BASEE and PS^3 established some kind of system for maintaining and refurbishing the science kits.** In most districts this was in the form of a refurbishment center, where kits were either housed and replenished on a rotational basis or where science materials for the kits were stored and available to classrooms as needed.
- School and district administrators noted that **professional development for teachers was well-rounded, addressing multiple dimensions of need** by providing science content, pedagogy (especially inquiry), integration of science and literacy, as well as kit usage.
- All three initiatives—**BASEE, PS^3, and NMTP—made outside expertise and resources available to teachers and administrators.** Those we interviewed saw this as a key benefit, explaining how "Science tends to be a subject matter in which districts are not terribly strong internally, so it's especially helpful to have outside people provide the guidance and the support."
- Many administrators cited **the importance of relationships and connections with other schools and districts that were established and flourished** during the BASEE/PS^3 efforts.

[2] Quotes are taken directly from interview transcripts and edited for both grammatical correctness and readability. Integrity of the quotes has been carefully maintained; intent and meaning have not been altered.

Like classroom teachers, districts also suffer from isolation, rarely communicating or collaborating with neighbors. In contrast, BASEE and PS^3 deliberately created opportunities for administrators, science resource teachers and classroom teachers to meet, learn and work together.

- Administrators who were knowledgeable about PS^3 described how **the professional education teachers received about the nature and development of professional learning communities was especially beneficial**. Teachers learned how to facilitate conversations with their peers through the use of protocols and with the aid of critical friends facilitators at each site. According to the former director, "We spent a lot of time teaching teachers various study group formats and strategies."
- School and district administrators we interviewed unanimously cited the **increased opportunities for teacher leadership in science**. "We had teachers who were implementing the science, and we also had teachers who were particularly trained to be leaders at the school site," one administrator reported. Another said, "I would say a majority of the teachers really gained in their leadership ability because of the work they had done in the programs ... their teacher leadership was an important offshoot."
- Finally, and most importantly, all the administrators we interviewed said that the primary benefit of BASEE, PS^3 and NMTP was that **more science teaching happened in their schools and districts**. Through these projects, districts could boast the existence of true science programs—especially among elementary teachers who previously had rarely taught science—with students receiving a steady diet of hands-on science appropriate to their developmental level, and with teachers increasingly enthusiastic and knowledgeable about science education.

The Perfect Storm: The Atrophy of Science Education in California

In 2008, as the PS^3 came to an end and as the *Noyce Master Teacher Program* got underway, powerful contextual factors converged to contribute to "the perfect storm" that wiped out or severely damaged much of the important infrastructure and supports for science education that the programs had steadily developed in the previous decade.

First and foremost, the nation as a whole faced a full-sized recession. The South Bay Area, especially Silicon Valley, was very hard hit. School districts were faced with large budget deficits and many were forced to slash their services, with money for Teachers on Special Assignment, professional development, or materials targeted for science often the first to go.

Simultaneously, federal education policy through the No Child Left Behind (NCLB) legislation drove increasing focus on state level academic testing through the California Standards Tests (CST), and reporting through the Standards Testing and Reporting (STAR). Coupled with various "accountability" policies such as the threat of a Program Improvement (PI) designation for failing test scores, these circumstances led to schools and districts feeling tremendous pressure to concentrate exclusively on the teaching of basic skills, reading and math. Science, along with other "elective" subjects, was relegated to the instructional back burner, and in some cases at the

elementary level disappeared completely. Moreover, low-SES schools, where test scores were likely to be lowest, were also most vulnerable to the loss of their science programs, thereby often creating marked disparities among "have" and "have not" districts, or even schools in a single district. A current Assistant Superintendent explained:

> *No Child Left Behind, and the policy that if you are a "program improvement school" you dump everything but teaching math and reading, really was a detriment to science instruction in this state. The kids who need that kind of dialogue around academic language, handling items, the realia, the inquiry, the thinking skills that come from teaching science—they didn't get it for ten years. That legislation impacted science learning for students in this state to the point that we will have a generation of kids not knowing science. That I think had a huge impact, because those schools where they needed it the most went into Program Improvement first, and they had the longest period of time without solid science instruction.*

Our interviews also revealed an important third factor: the change and churn in district level leadership. It was surprisingly difficult to contact many of the administrators who had been key supporters of the BASEE/PS^3 initiatives. They had either retired or moved on to other districts and other positions. Moreover, district administrations had often changed, sometimes two or three times, since the flush days before 2008. A current district level administrator in one of the formerly most active BASEE/PS^3 districts exemplified what we found in other places:

> *I regret to say that I don't know how I can be helpful to your study. I don't know anything about BASEE/PS^3/NMTP beyond having heard their names. I'm sorry I cannot be of help and I really don't know any administrator who can be, as there has been significant turnover in our district.*

The Assets that Remain

In spite of the unanimous agreement among administrators that the once robust and multi-dimensional science programs their districts had boasted during the lifetimes of BASEE/PS^3/NMTP no longer existed, they pointed to some important residuals:

- In most of the districts, the **FOSS kits and materials are still in place** and are being used by elementary teachers. As a current principal described, "I do believe FOSS is institutionalized to the point that if we were to ever look at a different training, the teachers would say, 'Hey, this is what we use!' I think as we look at supporting or developing a new program, FOSS is going to be a foundation of that."
- In many of the districts, **some system for maintaining and refurbishing the kits and materials still exists**.
- **Cooperation among the districts that had previously collaborated extensively also remains**, though to a lesser degree. For example, currently many districts share rotating responsibility for new teacher science kit trainings.

- A **tradition of teaching FOSS remains in elementary schools in many of the districts, as well as a more heightened propensity for teaching science**. One Superintendent, relatively new to a district previously heavily involved in PS^3 and NMTP, compared it to his former district. "... in spite of the draconian cuts science took here, there is a remnant of commitment to science teaching ... there is a clear feeling about the value of science education. It was very evident to me because I came from a district where we could pretty much get whatever we wanted to get, and we didn't have a fraction of what is here, what is still left of the science program in this much more financially strapped district."
- **Many teachers who were involved in BASEE/PS^3/NMTP are still teaching** in the districts. They have benefited from past, but nevertheless intensive, professional development as well as many accumulated years of good science teaching in their classrooms.
- In addition, **a pool of latent, currently untapped teacher leadership for science education still exists in the districts**. A former Director of Elementary Education in one of the BASEE/PS^3 districts stated what others also confirmed: "One of the most important accomplishments was that teachers were deeply trained to use the curriculum, and to do inquiry, and to work together ... also there was a cadre of leadership where teachers were particularly trained to be leaders at their school site ... and so you still have those teachers there who understand deeply..."

From speaking with former and current school and district administrators it became clear to us that BASEE/PS^3/NMTP did **not** create permanent systemic change. School and district systems are inherently unstable, always at the mercy of turbulent fiscal and policy environments. Science programs and, most importantly, science improvement efforts ebb and flow; they expand or contract with changing contextual features. In our view it is unrealistic therefore to aspire to a goal of enduring change in these systems. That does not mean however that it was not strategic for BASEE/PS^3, and to a much lesser degree NMTP, to work with districts. On the contrary, when a district is interested and aligned, the work of improvement efforts like BASEE/PS^3/NMTP can be highly leveraged. With district support, the programs were able to reach more teachers and to increase the overall amount and quality of science teaching in the district.

Like a successfully burning campfire, when the conditions were right the BASEE/PS^3/NMTP projects ignited science education in the participating districts and continued to fuel and fan the flames. But when the necessary conditions deteriorated, the projects alone could not sustain the science flame. However, as the administrators we interviewed pointed out, embers buried below the surface still glowed. The FOSS materials, the relic refurbishment systems, the relationships, the knowledge and experience of teachers and administrators were left as dormant but key capacities with potential to re-ignite a live science effort in more favorable conditions.

III. THE TEACHERS AND TEACHER STORIES

The Long-Term Perspective of the Teachers on the Projects

Just as we asked administrators about their experiences with BASEE/PS^3/NMTP and their retrospective assessment of the projects' quality and value, we asked teachers similar questions. Teachers were eager to talk with us. The response rate to our requests for interviews was very high. Nor did teachers seem to mind the length and depth of the interview process. Our pool of 21 consisted of experienced, often exemplary teachers. One was a California State Teacher of the Year, several others had been selected as Teacher of the Year in their home districts, and all of them described many accomplishments they had achieved, though, not surprisingly, never in boastful or self-aggrandizing ways.

Like the administrators, the teachers' overall retrospective evaluation of the BASEE/PS^3/NMTP programs was very high. When we asked them to think back on their association with BASEE/PS^3/NMTP and to rate the overall influence of those projects on their professional life on a scale of 1 to 5, with 5 being the highest, the response from 20 respondents was the following:

- 55% rated the influence of BASEE/PS^3/NMTP the highest, "5"
- 40% rated a "4"
- Only 1 out of 20 (5%) rated with a "3"
- There were no "1" or "2" ratings

We also asked teachers to describe how the influence of BASEE/PS^3/NMTP compared to the influence of other professional development experiences in which they participated, and to tell about one or two key or landmark events from their history with the projects. What emerged across all the interviews was a convergence on a list of key design features of BASEE/PS3/NMTP that teachers cited as especially significant to them. We describe them briefly here:

- **Teachers found professional community** through the BASEE/PS^3/NMTP projects. **They welcomed working and learning collegially**, and explained the value of hearing multiple perspectives, gathering new ideas, discussing their own thinking with others, and taking teaching risks together. Teachers' experiences corroborated what Jean Piaget, the eminent developmental psychologist, asserted throughout his work—that both children and adults learn optimally through social interaction. Moreover, the relief from isolation and the excitement of collaboration inspired many of the teacher participants to want to create the same kinds of learning communities in their own classrooms and schools. One middle school PS^3/NMTP teacher, representative of many, said: *Taking part in those sessions was my first sense of collegiality of being an educator. I understand that it is not necessarily the focus of PS^3, but I think that really established for me the sense of we are not alone in doing this, we are all learning together and working together. A sense of community really continued here at the junior high with the department that we have here.* Or as another current middle school teacher explained: *By having those (BASEE, PS^3 and Noyce) classes and that support, even though our district wasn't supporting us doing the science, the*

community was, and I was able to keep science in my classroom and argue for it.

- The **BASEE/PS^3/NMTP professional development experiences were intensive and long-term**. Especially in contrast to the limited professional development most teachers had encountered, such as attending conferences or day-long workshops, the immersion into professional learning over several years' participation in BASEE/PS^3/NMTP was memorable for teachers: *Long-term professional development is rare. Because of the longevity of it, it has felt very significant ... I also have regularly attended conferences, the California Science Teachers Association and the National Science Teachers Association conferences, and found them very valuable. They are great places to pick up ideas and resources and meet people, but those being short-term they don't feel as significant.*

- The **BASEE/PS^3/NMTP professional development was rich in content learning.** For elementary teachers, learning more science content addressed a great need they felt. Very few of them had science backgrounds, and many had rarely taught science in their classrooms because they felt unprepared**.** And for middle school teachers, participating in non-generic, subject-matter-specific professional development where science content was the focus was a very welcome boon, allowing them to dig deeper into the subject they loved.

- **BASEE/PS^3/NMTP professional development was also rich in innovative pedagogy**. Teachers learned about pedagogical strategies such as differentiation or the use of writing in science instruction. **The most significant pedagogy** teachers learned about, the one mentioned most frequently, **was inquiry**. BASEE and PS^3 in particular included important components focused on inquiry, which were eye-opening for participants. In BASEE, the FOSS kits relied on discovery methods, while in PS^3, week-long summer inquiry institutes were offered. One middle school teacher who began teaching during the second year of PS^3 described how transformative learning about inquiry was for a new science teacher: *I really enjoyed it, and it opened my mind as a new teacher. As a new teacher you really stick to the textbook because you are just trying to learn the curriculum ... it opened my mind to start thinking about how I could take the kids through a process, not just a book.*

- Teachers also described that an important feature of the BASEE/PS^3/NMTP professional development was that **teachers were asked to reflect on and inquire into their practice.** "It wasn't didactic, they weren't talking at you." Rather, teachers were treated as "professionals, as adults who knew something." And **this stance showed respect for and trust in teachers,** which interviewees found refreshing.

- **BASEE/PS^3/NMTP offered teachers unique access to both regional and national level resources and expertise in science** that they would not have had otherwise in their more isolated local settings. For example, triads of professional development facilitators for PS^3 summer institutes were deliberately designed to include college level science educators as well as working scientists. And throughout the BASEE/PS^3/NMTP, participants were invited to work with such entities as The Exploratorium, West Ed, NSRC, and the NSTA Learning Center to name just a few. Teacher participants valued highly these opportunities to learn from "the experts" and, in many cases, to develop strong individual relationships with them.

- Finally, teachers we interviewed talked about **the importance of the range of leadership opportunities BASEE/PS^3/NMTP offered them**. Some of these opportunities were quite formal, such as serving in the role of a Science Resource Teacher, or as the teacher educator member of the triad of professional development providers. But many other kinds of leadership opportunities were also provided by the projects. For example, teachers were invited to participate in events or courses specifically focused on developing leadership skills, such a program offered through West Ed, or Professional Learning Community (PLC) facilitation offered by the project. In addition there were scores of "lower risk" opportunities, such as teacher presentations about the kinds of things they had done in their classrooms or simply taking some new idea or activity back to a department or grade level meeting.

BASEE/PS^3/NMTP Offered Teachers High-Quality Professional Development

As we review the features of professional development the interviewees identified as the most important to them, we see that their list matches well to our own. Over the past 30 years of studying professional development we have developed a set of design features that we believe are reflective of high levels of program efficacy.

Moreover, we know that many of these same features are those also described in academic research as indicative of exemplary professional development.[3] Research converges on the kind of professional learning that improves teachers' practice and student learning. All three (of many) reports cited in the footnote below identify the following features, all of which the BASEE/PS^3/NMTP projects exemplified, and which the teachers we interviewed described as especially important to them:

- Provides sustained and intensive professional development (50+ hours)
- Promotes collaborative approaches; builds strong relationships among teachers
- Connects to classroom practice
- Focuses on teaching and learning specific academic content

Thus, based on 1) the ratings and testimonials of a large sample of exceptionally proficient teachers, and 2) the close match between the characteristics teachers noted to those called out as characteristic of effective professional learning by various academic researchers, we feel very comfortable stating that the BASEE/PS^3/NMTP efforts were very high-quality professional learning experiences for participants.

---

[3] Archibald, S., Coggshall, J., Croft, A., Goe, L. (2011). *High-Quality Professional Development for All Teachers: Effectively Allocating Resources.* National Comprehensive Center for Teacher Quality. www.gtlcenter.org/sites/default/files/docs/HighQualityProfessionalDevelopment.pdf

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., Orphanos, S. (2009). *Professional Learning in the Learning Profession: A Status Report on Teacher Development in the United States and Abroad.* National Staff Development Council. www.learningforward.org/docs/pdf/nsdcstudy2009.pdf

Loucks-Horsley, S., Stiles, K.E., Mundry, S., Hewson, P.W., Love, N. (2003). *Designing Professional Development for Teachers of Science and Mathematics.* Thousand Oaks, CA: Corwin Press, Sage Publications.

BASEE/PS^3/NMTP Influenced Teachers' Learning, Teaching and Leading

The purpose of this section of the report focusing on teachers is to describe in some detail how the BASEE/PS^3/NMTP experiences affected teachers' learning, teaching and leading. We also intend to portray how these highly interconnected and mutually influential processes created a self-sustaining, capacity-building dynamic that is often the outcome of highly successful professional development programs.

We deliberately make our own words sparse and the words of the teachers who knew BASEE/PS^3/NMTP directly paramount. The teacher vignettes[4] that populate this section are intended as the key to understanding how these projects contributed to teachers' learning, teaching and leading, and how in many instances BASEE/PS^3/NMTP teachers were empowered to continue to grow personally and professionally after the completion of the projects—to continue to learn, teach and lead—to serve as science champions in spite of the many adverse conditions and challenges they faced.

JERRY DAY, middle school science teacher and science department chair

> *Let me tell you my science budget. My science budget from the district is zero, and so the money I get to spend for microscopes, lab materials, whatever is nothing. We have a little budget for paper and whatever, but that is about it, so we actually fund ourselves. We ask for donations at the beginning of the year. I have family members that have donated money to my program and some of our other science teachers have some of their family members that have donated. Rarely do we ask the district for money because their answer has always been, we don't have it. My budget when I first started was about $7000 to $8000 for science, and now it is zero ... we just do it ourselves and then we can have control over what we want to do with the classroom.*

Jerry Day has been teaching 30 years in the same district he attended as a student. He started teaching in 1983, and has been the science department chair since 1988, providing his close-knit department with long-term leadership and vision. Pillars of that vision are the principles of collegiality, collaboration and community that Jerry has persistently worked to foster over the past three decades. At his insistence almost all of the teachers in the science department participated in the NMTP effort. Five of the six attended, while four of the six were previously involved in PS^3.

> *I wanted the whole staff to do the Noyce so that we could actually work together, because we are a very collegial team as far as our science program goes. All five of us got in to the Noyce program and that meant that we were able to strategize on what SciPack classes to take, to think about which of the programs would be best suited for where we felt we needed help ... We decided together which ones we might want to do according to what our focus area was for that year in science and where we wanted to improve.*

In terms of his personal experience, Jerry explained how using the SciPacks helped him see his teaching

[4] In our interviews we promised teachers anonymity, which we will preserve in the following vignettes by using pseudonyms and not naming their schools or districts.

from his students' point of view. "I have been out of school for a long time, 30 or 35 years, and so to actually go back to school on your own, through online learning at home, but still going back to learn something you don't know and to be the student again—it's kind of whoooa! You forget what it's like. It gave me an opportunity to put myself in my students' shoes." The experience changed how he taught his classes, and how the department innovated together to institute new pedagogies.

> *One of the biggest insights I had from the SciPack modules was thinking about a strategy they used—after reading two or three paragraphs you encountered a flash interactive on the topic where you had to answer questions on what you just covered. You couldn't go on until you got them right. That kind of changed the way that I began to do my instruction. In the department we use a lot of PowerPoint. In the past we would usually have questions embedded at the very end that we'd ask the kids. And of course they would raise their hands, all looking around at other people in the room to see what their answers were, so it really wasn't a very effective way to check for understanding. But that's all changed now, for me and for the rest of the department. We got classroom responders, and now we all pose a question and ask students to respond with their clicker so we can see the results right away to see if the kids understood the concept or not.*
>
> *It made me a better teacher because my second period comes in and I already know where the stumbling blocks are with these kids ... I am doing a better job or I am emphasizing certain things that I know that some of the kids had a hard time picking up. That for me was transformative.*

Jerry's experience with the SciPacks, reflecting on his own teaching, and making changes and improvements in his classroom practice was not an isolated effort. It was shared with the rest of his department.

> *It really helped me and it gave us, our science team, a focus for our work together. Besides just going to science conferences, we could actually spend time together doing science and talking about science, and so it brought about a whole conversation with my colleagues about how we could improve our program. We are not satisfied with where we are. We have a nice program, but there are always challenges and we always can get better. I think we have continually gotten better, and I think part of that is because of the in-service that was provided by PS^3 and Noyce.*

Teachers' Learning Was Influenced

Teachers described their BASEE/PS^3/NMTP professional development as a rich, varied and sustained series of learning opportunities. Teachers learned science content, they learned innovative best pedagogical practices, and they learned about the availability of many science resources. In addition, they learned about the presence of like-minded science teachers scattered across the South Bay.

In terms of science content, as we have mentioned, elementary teachers were happy to learn in an area where they had previously felt deficient. Learning about how to use the FOSS kits on a single science topic, as well as some of the science content embedded in the kit lessons, left teachers with a sense of efficacy, rather than guilt for not teaching science to their students. In contrast,

most middle school teachers who participated in PS^3/NMTP knew more science content than elementary teachers but still were excited to find themselves in a professional development setting that was not generic but, rather, subject-matter specific. They relished learning more science more deeply. Sometimes they wanted to learn in an area they had never studied or wanted to bone up on a subject, e.g., bio-chemistry, they hadn't taken since their own college years, or they knew they would have a teaching assignment they'd never had previously and needed to learn more about the subject. As one example, a middle school teacher told us how the SciPacks helped him prepare for teaching 7th grade biology.

> *... I am very accustomed to teaching chemistry and physics and I hadn't taught life science or biology ever. I hadn't taken a biology course in probably 20 or 25 years maybe. So the Noyce SciPacks I took in Heredity and Cellular Division, along with the support of the other teachers in my department, really gave me kind of a comfort factor, where I didn't just know the lesson plan, I was also comfortable with the material and my knowledge of the material. So I felt prepared if a student asked me an oddball question, or was very curious about something, or wanted to go a little bit deeper than what the lesson allows. I felt comfortable that I could work with that student to answer their question, so that comfort level was very nice to have.*

The BASEE/PS^3/NMTP efforts presented and modeled innovative and relevant pedagogy. Teachers said that being in the students' roles, either through the BASEE/PS^3 kit trainings or through the NSTA SciPacks, taught them important pedagogical strategies through doing and not just listening. Several middle school teachers, like the one we quote below, described how important it was for them to learn how to check for their students understanding.

> *Another teacher and I in our department have a grassroots type of effort at our site to try to reach students who are struggling, who won't come in outside of class, and don't ask for help, who are just content to be moving along and not getting it as long as their grades are okay. For elementary teachers this sounds like a no-brainer, but we discovered small group instruction where we do frequent formative assessment, so that as the teachers we could see right away who needs the support. ...That is what we started doing at our site last year. Now we are presenting our model of using clickers and embedding formative assessments into lessons and use those data to create interventions in small group instruction. I know elementary teachers have been doing this forever, but it is not that common in secondary school. It's kind of revolutionary.*

Teachers' Teaching Was Influenced

The teachers who spoke with us described not only what they had learned, but how excited they were about learning something they could and did implement swiftly in their own science classrooms. We asked interviewees directly about how their professional learning influenced their teaching, and we were often met with long explications of what happened. K-8 teachers incorporated more inquiry/discovery approaches and designs. They used and developed more

hands-on materials and experienced-based lessons. And many felt that they achieved more interactive classrooms.

JILLIAN WEEKS, a retired elementary teacher

"Working with young children in science is a match made in heaven. It is so successful that it is not a hard thing to do, and it is not a hard thing to champion," said Jillian Weeks. A teacher and leader since 1967 and now retired for a few years, Jillian was a seasoned successful teacher even before her BASEE experience. However, BASEE changed everything for her, as she describes:

> *BASEE changes the way you teach, and how you present science lessons. It shows you how to get the most out of children, and how you make it theirs and not yours. It shows you how to do open-ended kinds of questions where they figure out what it is. It is a whole philosophy that can be applied to everything else, and it is so much more successful than anything else. So I believe it changed the way I teach, the way I taught.*

Jillian's BASEE experience not only transformed her science teaching, it also helped her create ways for students to engage with science content through other subjects, like literacy and math. It was important to Jillian for students to "make science their own" through as many different pathways as possible. For example, Jillian's writing lessons focused on having the children write about their science experiments, which from her perspective was more motivating than "giving a packaged writing lesson." She also recalled questioning techniques that she felt changed the way she approached teaching all of the subjects she needed to teach in 1st grade. For her, teaching became a process of pulling ideas and knowledge out of the children rather than her putting it into them.

Learning about and trying out an inquiry approach to science teaching, allowing children to ask and pursue their own questions, opened up a completely new world for Jillian, even after over 20 years of teaching. Although it created more work and was challenging for her, it was worth it because she believed it resulted in better learning experiences for her students.

> *That whole inquiry thing was a revelation. That was an amazing thing, and that is a hard thing. It takes a lot of extra effort to do it, but the payoff is fabulous.*

We know both from administrators and teachers that in the elementary grades BASEE and PS^3 accounted for much more science teaching across the board. As for middle school, the amount of science teaching likely remained the same, but we think it very likely became better. We know that middle school teachers are often more reluctant to institute change than elementary teachers, so it was surprising for us to hear many compelling stories of innovation in teachers' classroom practices.

For example, the NMTP teachers we interviewed paid attention to the pedagogical strategies embedded in the SciPacks, especially the idea of student misconceptions. Through experiencing for themselves the way the online units were designed, teachers realized the need to understand

what common student misconceptions might be, to assess them, and to adjust their instruction accordingly. As one middle school teacher in a low-performing school explained:

> *Each of the SciPacks has sections that discuss the misconceptions that students have. In addition, occasionally there is a reminder about those misconceptions as you are going through the text. So the way the information is organized is useful. The sections on misconceptions help me understand ... "Oh, this is a common misunderstanding kids are likely to have." So I am going to have to hit it and clarify. I am much more aware of general misconceptions on different concepts, and hopefully it makes me teach better.*

Another example cited several times was how middle school teachers (as well as elementary teachers) made links between science and literacy because of their BASEE/PS^3/NMTP experiences. They established the use of science notebooks in their classrooms, as well as other kinds of strategies for writing in science. One middle school teacher was especially affected:

> *A big breakthrough for me was the year that we dealt with science writing, my first year PS^3. We went through a system called "Claim, Evidence and Reasoning," which kind of became a personal goal of mine. It was a big thing for me too, because I had not even been exposed to how to scaffold writing in science or to think of writing in science before that. I noticed that across the board, whether they were kids from Mountain View, kids from San Jose or kids from Palo Alto, all kids were struggling, according to their teachers, to write in a way that was understandable using academic language and explaining the science. "Claim, Evidence and Reasoning" is a writing format for kids to use to help them learn to explain their reasoning better. At our school it flowed well with what our language arts teachers were doing. So we were able to collaborate, to really work on helping kids to get better as writers. Later I had the pleasure of presenting on what we had done.*

Teachers' Leading Was Influenced

A key component of the BASEE and PS^3 programs was the support offered to teachers through the services of Science Resource Teachers (SRTs). The Teachers on Special Assignment (TOSAs) who became SRTs were carefully selected from the best in the participating districts. Each was assigned to three districts where they provided onsite coaching and professional development to teachers. They also played important roles in designing the BASEE and PS^3 summer institutes and workshops, working as a SRT team, sharing with others many of the innovative strategies and techniques they were learning as part of their own professional learning initiated and supported by the projects.

ROSEMARY PHILLILPS, an elementary teacher and a SRT for BASEE, PS^3, and her district

Like Rosemary Phillips, who served as an SRT for 14 years, many SRTs continued in their positions for multiple years, becoming experts in critical dimensions of science education improvement. The former Director of Elementary Education in her home district described Rosemary and her value as an SRT to the BASEE/ PS^3 efforts:

> *She was just phenomenal. She was so focused and so clear ... she was particularly good working with teachers. They loved her and respected her, and she respected them. She was their coach and very knowledgeable.*

The former director described some of Rosemary's key accomplishments. With the support of the (then) superintendent she got a waiver for the district to continue using the FOSS kits in elementary science, instead of the (then) state adopted text. "That enabled our district to continue to do a lot of hands-on science, when other districts virtually stopped teaching science." Rosemary frequently organized groups of teachers and administrators in the district to attend conferences and presentations on science. For many years she brought together and cultivated a group of lead teachers to present workshops on science, supporting the individuals to not only improve their own practice, but to share what they were doing with other teachers. She was instrumental in initiating and seeing to completion the construction of the district's science resource center, which became the hub for professional development, as well as the place where materials were stored and refurbished, and where a district garden was established. Finally, Rosemary initiated ways to reach out to other districts, helping to build intra-district relationships and supports, and organizing shared professional development offerings for teachers from multiple districts.

Currently Rosemary is on a 2-year leave, consulting to the Exploratorium Institute for Inquiry. It is likely that she will be assigned to a classroom teaching position if she returns because of the current district policy encouraging teachers to rotate frequently through Teacher On Special Assignments in order to train for potential administrative positions that the district needs to fill. She looks on her years as a SRT with gratitude. "I had access to all of these amazing resources that really shaped the way I think about teaching and learning ... I wouldn't be able to do the kinds of things that I do today, or have the connections that I have today without that experience."

When we asked about the influence of the BASEE and PS^3 experiences on her leadership, Rosemary explained in the following way:

> *We started off BASEE with Susan Loucks-Horsley, and I feel like she has always been in the back of my thinking about how you develop teacher leaders. The experiences of reflection and refinement on practice I had through all of those workshops —I must have taken 15 to 20 workshops! I kept honing this idea that I understand now. That is that teacher leadership starts in the classroom. So you can be a leader by reflecting and refining your practice. So if you are constantly trying to improve what you do with students, that is the first area of leadership. Then also, leadership involves sharing what you know and understand with your peers, both informally and formally. But if there isn't that reflection piece, then the leadership kind of turns into either disseminating information, or just telling other people how to do it, versus encouraging them to reflect and refine, on the way to incorporating new ideas about teaching into their practice in a way that works for them.*

When we think of teachers leading in their field, we think of a broad range of "leadership" roles and activities that take place in a broad range of venues. Our view extends from a recipient of the Presidential Award for Excellence in Mathematics and Science Teaching (PAEMST) or California State Teacher of the Year to a BASEE or PS^3 SRT to the head of a middle school science department or a teacher who tries paired sharing in chemistry class for the first time or a teacher who shares a new idea for a science lesson with the teacher next door. All of these activities are some form of leading in the science education field.

We explained our wide-ranging interpretation of leadership to the teachers we interviewed. We asked them to tell us about their leadership activities under the aegis of BASEE/PS^3/NMTP, and to explain the influences of their participation in BASEE/PS^3/NMTP on their leadership. How did their experience influence their interest in leadership? How did it influence their ability as a developing teacher leader? What were the lessons learned from their leadership and where did they apply them?

Many of the participants described how BASEE/PS^3/NMTP directly offered them opportunities for leadership. Some, as we have described, were tapped to serve as Science Resource Teachers, supporting teachers in their own and adjoining districts. Others were specially invited to participate in various learning or leading opportunities supported by BASEE/PS^3/NMTP. And, as we have previously mentioned, BASEE/PS^3/NMTP also engineered many and various ways for teachers to step up and to share what they were doing in their own classrooms, or to take on other kinds of low-risk roles within the BASEE/PS^3/NMTP programs. Much of this leadership work was collaborative. Of special note for the teachers we interviewed was how working together with other teachers in collaborative teams, e.g., as a group of SRTs developing a workshop, or in the triads which facilitated the PS^3 summer workshops, spurred their interest and confidence in taking on leadership positions.

KENT JACOBSON, a middle school science teacher and science department chair

Kent teaches 8th grade science and also serves as department chair at his middle school. He has been a teacher for 14 years. For Kent, participating in BASEE, PS^3 and NMTP positioned him and his department well in anticipation of the advent of the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS). He feels his participation in these projects helped him (and in turn is helping the department he leads) understand well and become skilled at collaboration, inquiry teaching, and incorporating writing in science—at least two of which are key components of the CCSS and NGSS.

Kent always liked teaching with inquiry but, as he put it, PS^3 gave him "the tools and the means to do it correctly." Inquiry is now a lens through which he examines any new lab or lesson idea he might consider implementing in his classroom or sharing with colleagues. He feels that he and his colleagues have been able to build on this foundation and continue to provide quality inquiry experiences to students at his school.

With respect to his department leadership, Kent feels that PS^3 strongly influenced the direction and nature of the kind of work he envisions for his team.

When I became a department chair, I was less worried about running the department and more concerned with how can we better ourselves, how can we stay ahead of the curve, and what kind of professional development we can give each other, and how we can work together to stay ahead of the curve. Everyone agrees that we are ahead of the game because of PS^3 and BASEE, so how can we stay together, what do we need to stay there, and what kind of collaboration would we need to do?

In PS^3, Kent learned how to facilitate a professional learning community, which is how he views and leads his department. He employs discussion protocols that he learned about to help teachers in his department solve problems or address dilemmas that arise from their teaching practice. He said that PS^3 influenced not only his leadership style but also his readiness to take on other leadership roles, such as with the current Integrated Middle School Science Partnership (IMSS) project, for which he is district liaison. In addition, Kent has led district-wide trainings on how to facilitate professional learning communities. These trainings recently ended due to lack of interest and changing district culture, but those who have been through the trainings continue to facilitate Professional Learning Communities around the district.

With the level of turnover that has occurred in the district, Kent noted that there are many more teachers now who have not experienced the BASEE or PS^3 professional development, and those remaining are in a kind of "fraternity." He feels this remaining group of teachers is committed to continuing the vision as new teachers come into the district.

The BASEE/PS^3/NMTP projects "opened doors" for teachers, thereby providing all kinds of opportunities for leadership outside the BASEE/PS^3/NMTP community. Teachers had chances to work with The Exploratorium, or the FOSS developers, or WestEd to name a few. Some even developed long-lasting professional relationships with these organizations.

The programs taught participating teachers about leadership in two important ways. First, by modeling exemplary professional development practices teachers learned about leading. The discussion, reflection and inquiry processes that characterized BASEE/PS^3/NMTP events were cited frequently as key components of a leadership style teachers hoped to emulate. Second, by providing explicit leadership training that was offered over the years, dozens of teachers were given tools and encouragement to take on leadership roles in their home contexts.

We collected a large inventory of examples of teacher leadership, ranging from formal to informal roles and responsibilities, situated in a spectrum of venues. The table on the following page illustrates both the range of type of leadership roles teachers have assumed, as well as the impressively large number of them. While some teachers did one or two things, many accomplished four or five, depending on their position and interests. The list of leadership roles illustrates (again) that working with other teachers was the most desirable kind of leadership work for these teachers, which is not surprising given what they described as their positive experiences collaborating with other teachers through the BASEE/PS^3/NMTP projects.

Sphere of Influence	Leadership Activity
BASEE/PS^3/NMTP	-Served as SRT for project, planning and conducting professional development -Served as assistant or lead teacher for summer institutes and other professional development
School	-Introduced new science courses -Worked with other teachers in department to improve student learning -Worked with other teachers in department to develop common assessments -Developed workshops for department on strategies to reach struggling students -Advocated for science on committees -Served as department chair -Asked by admins to be early adopter of trainings -Organized FOSS kits for the school -Supported ESL teacher with science lessons -Elected Teacher of the Year -Served on School Site Council
District	-Advocated for science on committees -Created 5th grade science camp that district funds -Served on committee for project-based learning for 7th grade -Served as SRT for BASEE/PS3 leading professional development for teachers and administrators; coaching -Served as curriculum committee representative -Facilitated grade-level teacher meetings -Assisted and/or taught BASEE/PS3 professional development sessions -Served on Science Adoption Committee -Expanded Family Science nights -Expanded Science Fair
Region	-Served as District Liaison for regional MSP grant -Served as Lead Teacher in regional MSP grant -Helped plan and teach BASEE/PS^3 summer institute
State	-Presented at CSTA conference -Served as BTSA support provider
Nation	-Served on NSTA planning committee -Presented at NSTA conference -Received NOAA grant ($60k) for field trips
Other	-Attended numerous workshops and institutes at other facilities such as the Exploratorium, LHS, Monterey Bay Aquarium, WestEd, etc.

The Significance of the Learning/Teaching/Leading Cycle

Through our studies of other programs over the past three decades, most notably the National Writing Project (NWP), we see that teacher leaders are developed via a dynamic cycle of learning, teaching and leading—processes that are mutually influential and beneficial.[5]

High-quality programs such as BASEE/PS^3/NMTP, like the NWP, and like those described by academic researchers (cited above), provide teachers with transformative **learning** experiences that enable them to discover interesting and compelling new subject-matter content and pedagogy. In turn, as teachers acquire new knowledge, they are stimulated to use what they have learned to improve their **teaching** practice, to teach their students (either adolescents or adults) what and how they have learned. Teachers then seek out opportunities for **leading**, especially in the broadly construed way we have discussed, in an effort to share with others the benefits they have reaped from their own learning and teaching.

In other words, this theory of professional development postulates that teacher leadership capacity building is based in classroom teaching practice and driven by opportunities to learn, which in turn inspire teachers to improve their teaching and to share what they have learned with others. It is an altruistic model of teacher growth and development.

It is a model that is surprisingly simple in outline and, in our experience, surprisingly difficult to achieve. Key to its success are two critical elements: 1) respect for and trust in teachers, as well as 2) long-term relationships with teachers. BASEE/PS^3/NMTP had both. The former director's words illustrate the approach:

Certainly we were hoping that some of these teachers who had trained with us through BASEE and PS^3, as well as the Noyce part of the program, would stay ... and ideally share what they were learning with their colleagues as well as their students. In some cases, some of them participated in leadership trainings of various kinds over the years and it was hoped that they would demonstrate that leadership in whatever flavor that the district could use it. I am of the belief that when teachers are given a better way to do something and they have their own evidence that it is better, they probably can't really help themselves from doing it ... That is my bias, but I also feel like it is another hope—when teachers have learned some better pedagogical skills that they are forever changed teachers with whatever students they are going to meet in their future.

[5] Heenan, B. (2009) *Reflections on the Success of NWP Teacher Leadership: A Dynamic Cycle of Teaching, Learning and Leading*. Inverness Research. www.inverness-research.org/abstracts/ab2009-03_Rpt_NWP-TeacherLeadershipEssay.html

CARRIE HARRINGTON, a middle school teacher and SRT

After just a few years of teaching under her belt, Carrie was introduced to PS^3 by a SRT serving her district. She participated in everything she possibly could, but the professional development meetings and summer institutes were especially eye-opening for Carrie since, as a new teacher, she had not been exposed to much inquiry-based science teaching ideas and techniques and the new approaches excited her. After a couple of years, due to her enthusiastic participation and growing skills as a teacher, she was asked to lead a PS^3 summer institute session. Later, with just two years left on the grant, she was asked to participate in PS^3 as a SRT.

In her role as a SRT, Carrie supported teachers in two districts outside her own, and helped plan and lead the professional development meetings and summer institutes. One experience in particular stood out to her as especially significant. She attended training at the UCLA School of Management to learn how to use protocols in small discussion groups. Back at home, she taught teachers what she learned about how to use the protocols within their study groups, which she felt deepened the work they were doing together to improve science teaching in those districts. The most valuable aspect of being an SRT for Carrie was the opportunity (and challenge) to think about, plan, and implement quality professional development for teachers.

> *Planning professional development for teachers and figuring out how to do that, and trying to be creative finding ways to engage teachers was a highlight. You know they are smart, and they know a lot, and so I had to think about how to present new things to them in a way that they were going to be receptive and also that would be helpful to them. There was a lot of learning for me that went around that.*

Carrie is a teacher whose induction years were deeply influenced by the kind of teaching and learning the PS^3 project espoused. Although some time in the future she hopes to have more opportunities to help other teachers improve their practice, Carrie is back in the classroom. She feels she is a much better and more confident classroom teacher as a result of her years with PS^3.

> *I am still using so much of what I learned—all of the inquiry type teaching. And my whole outlook on how to teach science and use the inquiry cycle has completely changed. I think I was fortunate because I was with* PS^3 *right at the beginning of my science teaching career, and so I was super open to any way that I could become a better teacher. I still am, but I think it is a different time in my career now and I feel a lot more confident.*

IV. THE LEGACIES

Based on our interviews with BASEE/PS^3/NMTP administrators and teachers, our conclusion is that the primary legacy of the 15 years of investment in K-8 science education is ongoing teacher leadership. The human capital of "leading teachers" or science champions is what remains alive and active. Many of the teachers we interviewed, who represent still others with whom we didn't speak, remain in classrooms or administrative positions and they are, as the former director said, "forever changed."

We would argue that the individual appears to be the most important unit of change, not the school or district. Individuals remain transformed and remain committed to championing their cause. In the case of BASEE/PS^3/NMTP, the cause is promoting science education. Residing within individuals are not only the will and interest to advocate for science education improvement, but also the knowledge, skills and expertise they developed that can be focused on the effort and put to good use when opportunities arise. There are teachers (and administrators) left in the South Bay who know and understand kit-based teaching, inquiry, literacy strategies for promoting science learning, the value of materials and refurbishment facilities, models of effective professional learning in science, science content, etc. As individuals they endure as often lone but persistent advocates for science; as a collective they constitute a large pool of currently untapped potential.

In contrast, district capacities, propensities, and even identities wax and wane. The districts of today, for example, are far different from the districts in which BASEE began. The people are different, the finances are different, and the interests and goals are far different. Almost all have changed two, three or even four times over. That being said, it is still true that the district provides either a supportive or an unsupportive context. As we have mentioned, it was not unwise for BASEE and PS^3 to use a systemic approach, to deliberately include and educate district administrators and school principals so they might develop district priorities and policies in support of science teaching and learning.

Similar to the fluctuations in our national economy, science education reform undergoes cycles of expansion and recession. It is not a steady state. But interventions like BASEE/PS^3/NMTP can help to:

1. bolster and strengthen science education during times of expansion,
2. weather challenges during recession cycles, and
3. set the foundation for revitalization of science improvement efforts when the cycle comes around again and is more propitious.

As we have seen with BASEE/PS^3/NMTP, the reforms suffered during the "perfect storm" of contextual factors that sent science education to the back burners of educators' attention. But as we have also seen, the BASEE/PS^3/NMTP investments left behind important legacies, primarily in the sphere of human capital, specifically teacher leadership capacity, which could be revitalized and employed again.

V. THE HOPE FOR A SCIENCE EDUCATION RENAISSANCE

The administrators and teachers we interviewed spoke about a resurgence of interest in K-8 science education. They described converging positive factors that gave them hope for renewed commitment to science.

Several cited districts' response to the inequities among schools that resulted from the repercussions of state and federal imperatives to improve student math and reading scores. A former PS^{3}classroom teacher who became an elementary principal explained:

> *... the teachers at our affluent school for the most part always taught science, they didn't have that pressure because they weren't low-performing schools. ... Our more affluent students always got great science content. They never stopped doing the science kits. The parents expected it and the kids expected it, and all of the teachers were onboard, so science was taught in every classroom. But in our poor schools, our Title I schools, our have-not schools, those kids didn't get science. A few years ago, a shift happened that has changed that. So everybody is teaching science now, because it's an equity issue. When as a district we started looking at our issues around equity, we realized it was immoral. That is wrong. Our poor kids might be the ones who need science the most, and science might be the thing that engages them in school and helps them get to college and changes their lives. So I think as a district in the past few years, especially with the superintendent that we have now, we have definitely moved back to science as an emphasis.*

Teachers and administrators also noted that the emergence of the Common Core State Standards and the Next Generation Science Standards has encouraged many districts to turn their attention back to science: "The pendulum is swinging back." Both sets of standards call for teaching higher-level cognitive skills and processes which science inherently addresses, giving teachers permission to teach science again.

Although California's education finances have improved somewhat in the last year or two, which is promising overall, budget constraints still affect how much districts are willing to spend on revitalizing neglected science programs. As one administrator said bluntly, "Let's face it, science costs money." Nevertheless, districts are also realizing that many thousands of dollars they themselves had invested in science education were assets that could be restored, and doing so would be fiscally sound.

In addition to the factors that are helping to slowly re-ignite interest in science—such as the improving economy and state fiscal picture, the recognition of inequitable opportunities for student learning, and the emergence of the CCSS and NGSS—teachers and administrators noted the presence of several large grant-funded STEM improvement efforts underway in the Bay Area, in which some of the BASEE/PS^3/NMTP districts participate. For example, the *Integrated Middle School Science Partnership* is a collaboration among California State University East Bay, four county offices of education, and administrators and teachers from ten districts in four counties.

This partnership focuses on teacher professional development to transform middle school science teaching and learning based on a lesson study approach. *BaySci* is a network of educational institutions, districts and teachers focused on improving elementary science education. There are currently ten districts, six science-rich educational institutions, and others engaged in various activities to improve and advocate for elementary science in the Bay Area. The Lawrence Hall of Science has been supporting what is referred to by practitioners as the *FOSS Collaborative,* which involves training on the FOSS kits for districts and schools that were not a part of BASEE/PS^3/NMTP. The view of those we interviewed was that these efforts not only built upon the foundational assets created during the BASEE/PS^3/NMTP era, but also are keeping the flame alive by maintaining interest in and support for science.

VI. CONCLUSION

In conclusion we return to the major questions that framed this retrospective legacy study. What are the legacies of the investment made in the region? What are the obvious assets or affordances that remain? What lessons can be learned about investing in the improvement of science education, and what are the implications for funders? Our summary thoughts in response to these questions are bifurcated. First we offer a close up, short-range perspective, and second, we offer more of a landscape, long-range view.

Our Close-Range Perspective

First, focusing specifically on the BASEE/PS^3/NMTP series of investments in the San Francisco South Bay Area, we see the difficulties of investing in district level systems because of their volatility. Subject to constant policy churn and personnel transiency, districts are precariously stable for only brief durations of time. We learned that currently, the carefully constructed sets of systemic supports that once existed in the BASEE/PS^3 participating districts are by and large no longer present. Gone are the supportive superintendents, the directors of instruction who played active roles in promoting science and helping teachers, the new science kits and materials, the full and expanding refurbishment centers, the well-organized systems for maintaining the kits, as well as the time and perhaps extra monies districts gave to the science improvement push. And of course the generous infusion of NSF funding that provided teachers with rich, varied and multi-year professional development is also gone.

In spite of the depletion of these capacities, this study shows that very high-quality work was achieved by the projects, and that residual assets remain today. As we have said, the major residual asset is found in the human capital that was created—the individuals who were "forever changed" by their participation and who still reside in various roles within the former BASEE/PS^3/NMTP schools and districts. In addition there are some organizational structures that remain as assets, such as the presence of science kits in elementary schools, and instructional materials centers that may still house and/or replenish materials. And finally there are the intangibles—the institutional memory of robust science programs, the inclination of many

individuals to teach and promote science, and the latent skills and expertise of the people who learned so much during the BASEE/PS^3/NMTP years.

With the uptick in both the economy and the policy environment, as well as with the appearance of the Common Core State Standards and New Generation Science Standards to which districts feel obliged to respond, the implication for funders, especially local funders, is to invest now. Local external funding can make a huge difference when the conditions are favorable, and the pendulum is now swinging back towards an increased interest in science education improvement. Funders can now take advantage of the affordances that exist as remaining assets from the many years of previous investment.

On a very practical level then, new funding could tap into and support the strong foundation of leadership, both in classroom teachers and SRTs who are still functioning. The existence of elementary science kits in districts provides funders with "low hanging fruit" because many educators still have the know-how to get science kit-based teaching going. And while many of the districts are still using FOSS kits, their usage is spotty in others, so that an infusion of funds to train new teachers as well as a new generation of leaders to support and implement programs could go far in achieving active science programs again. Finally, a re-focus on science is very likely to occur on some level throughout the South Bay districts as the CCSS and NGSS are "implemented." Funders have an opportunity to lead the effort and to help shape the quality of how these policies are manifested in schools.

Our Far-Range Perspective

Now we step far back to consider the broad implications for funders and policymakers of this retrospective regional study of 15 years of continuous funding in science improvement. We come to the conclusion that there is a need to fund all levels of the system—state, region, district, school and individual. But the important qualification is to make the funding effort **without** the expectation of lasting "systemic change." It is not reasonable for funders to expect that their temporary infusion of dollars into turbulent systems will create "permanent fixes," or even long lasting institutional change. As we have seen not only from this retrospective study, but from a myriad of other investments we have studied over the past twenty years, the systems are too unstable, and the churn of federal and state policies is too great to allow for institutionalization and ongoing support for the programs put in place by external funding. At all levels there is rapid, almost constant turnover in people. There is an equal tempo to the pace of changes in policy-level priorities and goals that regularly shift the dialogue, the definition of students' improvement and success, as well as the reward structure. (The current best example is the shift in national policy from No Child Left Behind to the Common Core State Standards.)

In the face of such persistent flux, long-term investments can, however, build "capital" that can help perpetuate not only the programs and curricula that are put in place, but also, and most importantly, the human capital and energy needed for continuing improvement efforts. In our view, it is particularly important that funders pay attention to the power of their investments in creating individual teacher leaders and the connective tissues such as teacher networks or

professional learning communities that can support them. As this study has shown, teachers tend to persevere and to adapt to the rapidly changing environments in which they must do their jobs; they live by their commitments to their students not to the policies of the moment. No matter what the "reform du jour" might be, teacher leaders serve as the engine for its implementation, working to realize the vision and goals "on the ground," in their schools and classrooms.

Hence, we think that funders should focus on the following three ideas:

1. Consider investment over the long term, not in 2- or 3-year increments. Spanning 15 years, the BASEE/PS^3/NMTP stream of monies for science education improvement showed how continuous support can reap very strong benefits in capacities, or capital, achieving sufficient durability to weather lean and unpropitious times.

2. Funding can be most effective when focused on creating supportive environments for improvement, hence our belief that all levels of the system should be addressed but **without the expectation** of permanent change. Rather, funding should be given **with the expectation** that systems will always be in flux, and that strong leaders in a supportive state, district, and/or school environment will be able to continue to work as change happens for the improvement of science education.

3. Aiming funding toward creating the capacity for ongoing improvements in instruction, largely through the development of teacher leaders and the networks that can connect them, actually **does** result in an ongoing process of local improvement. BASEE/PS^3/NMTP serves as proof positive of this assertion, showing us how changed views and practices reside within individuals, remaining there as a long-lasting capacity. Supporting teachers and others in experiencing the dynamic, self-perpetuating cycle of professional learning, teaching and leading enables individuals to become science champions, to continue to promote and enact good science teaching and learning in whatever situations or circumstances they find themselves.