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Developing Teacher Leaders in Science: Attaining and Sustaining Science Reform

An argument is made that teacher leadership at both the system and school level is an important part of the science systemic process intended in science education reform. This article describes the design of such a professional development program, the challenges addressed, and the impact on teacher leaders.

Introduction

The wave of reform that has swept across the United States over the last two decades has created a climate of change that requires school districts, schools, administrators, and classroom teachers to reexamine their core beliefs regarding teaching and learning. These reform efforts in one way or another all require systemic change. Bybee (1996) describes that as schools and districts plan for systemic change, they must consider changes in purpose, policies, programs and practices. Purposes relate to the general agreement on the need for science literacy for all; state and national science content standards are the policies that guide education toward those purposes. However, in order to move to students, programs need to influence practice. This is the only way that students will have improved opportunities to learn. The development of teacher leaders may be one of the critical links in this chain, one that can take purposes and policies and influence student learning through its impact on teaching.

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The development of teacher leaders requires a different method of addressing the challenge of systemic reform. This method requires school districts to utilize an "inside-out" type of systemic reform. This type of systemic reform results in changes in the system because people are changing and are influencing the structures, procedures and the policies that guide teaching and learning. Fullan (1993) emphasizes the importance of all educators being change agents; that it takes all stakeholders to make change in order for systemic reform to happen. Nesbit, DiBiase, Miller, and Wallace (2001) suggest that in order for systemic reform to take place at the school level, teachers and principals must take on new roles. Therefore, it is critical to develop a mechanism to create a cadre of teacher leaders who will play an important role in this change process.

The *National Science Education Standards* (National Research Council, 1996) also recognize the importance of teacher leadership in several standards. While classroom teachers have defined roles and responsibilities, clearly defined leadership roles are required for systemic reform to take place. Program Standard-A indicates that responsibility needs to be clearly defined for determining, supporting, maintaining, and upgrading all elements of the science program. This means that the district or system must recognize the importance of leadership and create mechanisms for the development of teacher leadership. Teaching Standard–F establishes an expectation that teachers assume a leadership role in improving science programs. This will require districts and systems to develop mechanisms that will enable teachers to increase their ability to work with others to improve science teaching and student learning.

What Does Research Tell Us About Teacher Leadership

Instead of the traditional role of being receivers of change, teacher leaders will become key decision makers, and in the "inside out" view of systemic reform, become the owners of change and work with their colleagues to share that ownership.

In order to design a professional development program that prepares teacher leaders to assume leadership roles, those characteristics of leadership must be identified that are necessary for teachers to become the change agents for the systemic reform process and provide opportunities for teachers to lead at the school level. In order to attain school wide results Darling-Hammond and McLaughlin (1995) recommend that such professional development programs must consider a variety of elements that include the traditional elements of the deepening of content and pedagogy, but go beyond these traditional approaches to include adult development, problem solving, and collaboration. Other characteristics of teacher leadership development that should be considered are decision making, building vision, how to conduct and organize professional development, skills for team building, resolving conflicts, and problem solving (Loucks-Horsely, Hewson, Love and Stiles, 1998). Pellicer and Anderson (2001) report that teacher leaders also need opportunities to practice leadership. Klentschy and Molina-De La Torre (2003) suggest that in order for systemic change to take place, teachers need time for collaboration within and between schools in a system. Teacher leaders are the catalyst for this type of collaboration and need both the knowledge and practice base to facilitate this type of collaboration. Zinn (1997) reports that there are four key factors that must exist within the system to support the development of teacher leadership:

- a climate that is supportive of teachers as key decision makers
- principals or other administrators who are supportive
- teachers supporting each other
- a supportive relationship between colleagues.

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Informed by teacher leader research, a consortium of school districts in Imperial County, California recognized the importance of the development of teacher leadership as a key element in their science system reform efforts through a National Science Foundation Local System Initiative called the Valle' Imperial Project in Science (VIPS) more than a decade ago and has been well documented in the literature (Amaral, Garrison, and Klentschy, 2002; Jorgeson and Vanosdall, 2002; Jorgenson and Smith, 2002; Saul, et al, 2002; Klentschy and Thompson, 2008).

Imperial County, California is a geographically isolated agricultural region of southeastern California bordered by Mexico on the south and Arizona on the east. It is one of California's largest counties in terms of area, but it is sparsely populated, and its residents are among the poorest in the state in terms of real income.

The students in Imperial County are predominately Hispanic English Learners, and most of them are eligible for the federal free and reduced price lunch program. There are fourteen districts participating in VIPS. Six rural single school districts; six districts have between three and six schools each; and two larger districts, one with ten schools, and the other with eleven. El Centro is the economic and administrative hub of the county, and the El Centro Elementary School District is the largest district serving K-8 students. El Centro is also the lead VIPS district. This countywide collaborative partnership also included San Diego State University, Imperial Valley Campus and the California Institute of Technology. This county-wide collaborative partnership has remained in tact since 1996 and is currently a member of the California Mathematics-Science Partnership network.

The Valle' Imperial Project in Science recognized that the development of teacher leadership was needed at two different levels: 1) teachers on special assignment (TOSA) were needed to provide leadership at the system or consortia level; and 2) teacher leaders were needed at the school level to become liaisons between the consortia level and the school level and to help lead the reform efforts in their individual schools. The VIPS leadership was challenged with the question of what should a professional development program look like to create a dual level of teacher leaders possessing the knowledge and skills to bring about and sustain the changes needed to attain the initiative's goals.

The Teacher Leadership Professional Development Model

The development of teacher leaders at both of the school and system levels required the VIPS leadership to carefully craft a professional development design that addressed the differences in roles and responsibilities that would be required at each of these two levels. When the science reform initiative began there were no existing teacher leadership development programs in the region for science or any other curricular area to draw upon for teacher leadership professional development program design. Therefore, a new model was needed. After carefully examining the scale up design of the science reform initiative, the VIPS leadership started with the program design to develop teacher leadership at the system level. The scale up design of the science reform initiative started with the establishment of three pilot schools. These pilot schools would become the starting point for the implementation of the science reform initiative. Thus, teacher leadership at the system level would be needed to support the teachers at these three pilot schools in the early phase of the scale up. Teacher leadership at the pilot school level would also be developed during this early phase of scale up. The design was aligned to scale and would expand as the scale of the science initiative expanded over time.

A TOSA was hired by the initiative six months prior to the scale up at the three pilot schools. The TOSA had a background in science education, was enthusiastic, but had little experience in leading professional development or in mentoring and providing collaborative support to other teachers. The TOSA became an active member of the local VIPS leadership group including the university partners at San Diego State University, Imperial Valley Campus, and at the California Institute of Technology. The TOSA also became a collaborator in the development of teacher leadership at the school level. In order to prepare the TOSA to take on this role and the associated responsibilities, they were released for a month and actually job shadowed a TOSA in another reform initiative, Project SEED in Pasadena, CA. This job shadowing provided the TOSA an opportunity to learn on the job what a TOSA does and how they support teachers. In addition, the TOSA participated in several workshops at the Exploratorium in San Francisco, California. These workshops were designed to prepare teacher teachers to lead systemic change, experience immersion in inquiry, and plan effective professional development. The value added dimension of these two experiences also afforded the new TOSA to immediately become part of a larger professional network of educators all working in science reform from across the United States.

In the early phase of scale up, the development of teacher leadership at the three pilot schools was also important. Teacher volunteers at these pilot schools became the first cadre of school level Lead Teachers. The professional development was designed to meet the growing needs of teachers to move along three distinct professional growth continua described by Berlinger (1994); content knowledge, pedagogical knowledge, and student learning knowledge. In fact, in a standards based environment, there was a fourth continuum or pathway that was also considered, pedagogical content knowledge (Marks, 1990). There was a belief by the VIPS leadership that professional development could be optimized when it was long-term, school-based, collaborative, focused on student learning, and linked to curricula (Darling-Hammond and Sykes, 1999. Such programs focus teacher activity around the examination of student work, student performance, joint planning, teaching and revising lessons, and individual and group reflection. This paradigm shift from working in isolation to working in a collaborative group was favorably received by teacher leaders. The VIPS leadership including the new TOSA worked with the Lead Teachers at the pilot schools in a collaborative model. Lead Teachers and TOSA's from Project SEED also mentored new Lead Teachers.

Lead Teachers became the liaisons and direct link between the science reform initiative and the classroom teachers. Individual school level and system wide professional development was implemented for all teachers at the three pilot schools with Lead Teachers participating in leadership roles, assisting and shadowing the TOSA and the Lead Teachers from Project SEED. This process lasted for a period of three years.

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During this period of time, VIPS leadership recognized that the next level of scale up would encompass forty-two schools, not just three. Additional TOSA's would be needed to provide training and collaborative support to thirty-nine new schools entering the science reform initiative. A new cadre of Lead Teachers would need to be selected to become the liaisons between the initiative and their schools. Recognizing this need, one of the partner universities, San Diego State University, Imperial Valley Campus (SDSU-IVC) launched a new Master's Degree program in Curriculum and Instruction with a Specialization in Science Education. The program focused on the development of the same four pathways of teacher development as the professional development design of the teacher leadership development program of VIPS. Twenty-five teachers began the program and twenty-two completed it. This group of teachers along with the Lead Teachers from the three pilot schools provided VIPS with the pool of teacher leaders needed for the scale up to forty-two schools.

With scale up to forty-two schools, there was also a scale up in the number of TOSAs from one to three. The first TOSA became the Project Director and three new TOSA's were selected. Two of the TOSAs came from the pilot schools and one from the Master's Program at SDSU-IVC. This provided an excellent career pathway for teacher leadership. The initial training of these new TOSAs was similar to the training received by the first. Job shadowing of existing TOSAs in Project SEED and professional training at the Exploratorium were again utilized. In addition, these new TOSAs became involved in science education professional networks through state and national professional organizations. Each of these TOSAs and the Project Director were assigned to a group of schools to provide collaborative support to Lead Teachers and classroom teachers through regular campus visits. In addition to these responsibilities, the TOSAs and Project Director were involved with planning and leading professional development for more than 1200 classroom teachers now participating in the science reform project.

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A seventy hour professional development program was designed for new Lead Teachers. The VIPS leadership recognized that professional development should be integrated into the regular practices of teachers.

Since the 2000-2001 school year several iterations of the initial professional development design for Lead Teachers have evolved. A critical component of this evolution was the creation of a plan of action to transform practitioner knowledge into a professional knowledge base for both TOSAs and Lead Teachers and then have both groups work at the school level to do the same with classroom teachers. The core of the professional development design to attain this goal has always included five dimensions: 1) a focus on working with adults and polishing professional development presentation skills as outlined by Garmston and Wellman (1999); 2) deepening teacher pedagogical content knowledge related to the science content students need to know (Vanosdall, Klentschy, Hedges and Weisbaum, 2007; Klentschy and Thompson, 2008); 3) creating reflective practice through collaboration, lesson study, and the examination of student work (Stigler and Heibert, 1999; Heibert, Galimore and Stigler 2002; Amaral and Garrison, 2004); 4) literacy connections designed to assist students in making evidence-based explanations of their science experiences through science notebooks, talk, and embedding English Language Development strategies into the context of science content instruction (Amaral, Garrison, and Duron-Flores, 2006; Duron-Flores and Macias, 2006; Klentschy and Molina-De La Torre, 2004; and Klentschy, 2008); and 5) scaffolding inquiry (Klentschy and Thompson, 2008). These sessions were designed to provide a variety of pathways for teacher expertise development and yet at the same time focused on three outcomes:

1. To learn to analyze practice—both other teachers' practice and their own. In this context, analyze means to think about the relationship between teaching and learning
2. To be exposed to alternatives
3. To develop situational judgment to know when to employ which method

These three outcomes were based upon a belief that changing teaching means changing the culture of teaching to a knowledge-based practice.

In considering the operational characteristics associated with disciplinary expertise as a foundational framework, the notion of knowledge-based practice or practitioner knowledge provides a methodological perspective for approaching curriculum and instruction for teachers. The distinguishing characteristic of knowledge-based instruction models is that all aspects of instruction (e.g., teaching strategies, student activities, assessment) are related explicitly to an overall design that represents the logical structure of the concepts in the subject-matter discipline to be taught. The explicit representation of the knowledge to be learned through the standards movement serves as an organizational framework for all elements of instruction, including the determination of learning sequences, the selection of teaching methods, the specific activities required of learners, and the evaluative assessment of student learning success.

Practitioner knowledge is useful because it develops a response to specific problems of practice. In addition to addressing problems of practice, knowledge linked with practice is grounded in the context in which teachers work. These are collaborative practices and involve teachers in the following activities:

- Defining the problem and creating a shared language to describe the problem
- Analyzing the classroom practice related to the problem
- Creating alternatives to solve the problem
- Testing the alternatives and reflecting on their effects
- Recording what is learned in a way that is shareable with other teachers

This form of knowledge is linked to practice because it is created from the problems of practice and connected to the process of teaching and learning occurring in classrooms.

Lesson study and other such efforts to promote professional learning communities at the school level have proven most effective to develop practitioner knowledge by including the sharing and dissemination of results among participants working in collaborative groups led by Lead Teachers and TOSAs. A unique element of lesson study is that discussions are data based, and connected to actual lessons. The cycle of improvement is linked integrally to a growing body of classroom data, usually student work. Lesson study has gained favor with teachers because it provides opportunities for teachers to practice, receive feedback, and share with their colleagues. Lesson study groups generate knowledge that shares key features with practitioner knowledge in that the group members work on a problem that is directly linked to their practice.

Over the last several years, almost 100 classroom teachers and 6 TOSAs have participated in the Lead Teacher professional development program.

Challenges and Outcomes

With any science reform initiative there are unexpected challenges as change takes place in real time. VIPS leadership anticipated four challenges in the development of Lead Teachers: 1) teacher mobility; 2) competing priorities; 3) a national focus on reading and mathematics; and 4) time. All four of these challenges surfaced over the last decade and a plan of action was in place to address each.

Teacher mobility is a fact of life in public education. Teachers change grade levels and schools, and some leave the profession for a variety of reasons. To address this challenge, VIPS leaders recognized that a pipeline of Lead Teachers and possibly TOSAs, needed to be developed over time. A new cadre of Lead Teachers was recruited by TOSAs each year to fill this pipeline. The VIPS leadership established a goal of having at least two Lead Teachers at each school in order to address the challenge of teacher mobility. While this goal has not been met at every participating school, a significant number of schools have at least two teachers who have participated in the Lead Teacher professional development program.

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In an era of standards, assessment and accountability, several new initiatives have been created at the state and federal level. In many cases, these initiatives have a leadership development strand or requirement. Thus, the recruitment of potential new Lead Teachers for science may be competing for the same teachers with other initiatives. To address this challenge, VIPS leadership conducted several awareness sessions for district administrators and school principals. These awareness sessions centered on the notion that science was the perfect content area to address the needs of students and teachers based upon the principles of how students learn most effectively-activating prior knowledge, teaching to the big ideas, and utilizing metacognitive approaches to teaching and learning (National Research Council, 2005). The principles of student learning were deeply embedded into the five dimensions of the Lead Teacher professional development. The awareness sessions for administrators demonstrated the transfer of these principles to other reform initiatives, thus increasing the support by administrators for the science initiative.

The focal point for the creation of teacher leaders in science requires districts and systems to develop mechanisms that will enable teachers to increase their ability to work with others to improve science teaching and student learning to accomplish the goal of scientific literacy for all students.

The national focus on reading and mathematics instruction and student proficiency levels required by states and the federal government have reduced the emphasis placed on science instruction and science professional development in many parts of the United States. To address this challenge, VIPS leadership recruited several reading coaches as science Lead Teachers and also conducted several awareness sessions for school reading coaches and mathematics specialists. Again, the three principles of student learning identified by the National Research Council (2005) were used as the focus of these sessions. Reading coaches soon recognized that science was a perfect content area to apply the communication skills of reading, writing, listening, and speaking. The mathematics coaches also recognized the importance of application of mathematics skills and the thinking strategies embedded into the science instruction. As a result of these efforts, there is greater collaboration at schools with TOSAs, Lead Teachers, reading coaches, and mathematics coaches, all working together to address the need to create a change in culture and teaching practice.

Time still remains a challenge. Many teachers feel pressed to cover required content. The awareness sessions for administrators and the inclusion of reading coaches and mathematics coaches have helped somewhat to address this challenge, but the challenge of time still remains an issue.

There have been positive outcomes for the TOSA and Lead Teacher professional development program. This leadership development program has become an important career pathway for the former participants. One of the TOSAs is now the Project Director for the science program. Another TOSA is now a principal. A third is now an assistant principal. Several of the Lead Teachers have become reading coaches at the school level. Two have become principals. Five are working in curriculum leadership positions at the district and county level. Three have become new TOSAs for the science program. The leadership training for each of these teachers has provided them with the ability to succeed in these new positions.

The other significant outcome for the leadership development program has been the creation of a strong cadre of site based leaders in science. This cadre has been instrumental in influencing teaching practice in their schools. One of the major goals of the science reform initiative was to create such a base.

Connections to Student Learning

While it is difficult to draw specific causal relationships between the development of teacher leadership and increased student achievement, Lead Teachers have been instrumental in assisting VIPS leadership staff in redesigning curriculum and practice designed to do so. VIPS leadership have been working on redesigning and realigning science curriculum to better match state science content standards and to utilize best practices for student learning. Lead Teachers were involved in focus groups to provide feedback to the VIPS leadership as scaffolded guided inquiry (SGI) curriculum replacement units were developed and field tested. The impact of the SGI replacement units on student achievement were the focal point of a three year longitudinal research study conducted in Imperial County and in Wake County, North Carolina. The data from these studies indicated that these SGI replacement units and teacher practice contributed to significant increases in student achievement (Vanosdall, Klentschy, Hedges and Weisbaum, 2007; Klentschy and Thompson, 2008).

Implications for Reform

The focal point for the creation of teacher leaders in science requires districts and systems to develop mechanisms that will enable teachers to increase their ability to work with others to improve science teaching and student learning to accomplish the goal of scientific literacy for all students. School districts and systems must also recognize that for change to occur at the system or district level, it must occur at the school level. Therefore, a well designed program of teacher leadership development must be provided for classroom teachers to develop the leadership necessary to accomplish this task.

For students to reach the goals to which the standards require and that school districts wish to attain, teacher learning and change are essential.

Sustainability has been a challenge for many initiatives. Quite possibly the key to sustainability for any initiative is the degree that teacher leadership carries and sustains the initiative after the initial funding is gone. One effective way to measure the true impact of a science teacher leadership development program is to measure its impact on the participants.

One Lead Teacher leadership development participant shares:

> *"For the past three years, I have been actively involved with VIPS as a Lead Teacher and trainer. I wholeheartedly value the experience of working with the TOSAs and other Lead Teachers. I have grown confident in my public speaking, in my leadership skills, both inside and outside the classroom, and in assisting my fellow teachers better address the needs of our students."*

Another Lead Teacher concludes:

> *"VIPS has helped me develop a deeper understanding on the productive way to teach science to my students while awakening student interest through inquiry. I have acquired ELD strategies to use with my students and these strategies also apply to other subject areas, not just science. My training has allowed me to develop a stronger professional relationship with other teachers at my school. We have become a very dynamic group and all of us have a common focus. This training has also improved my presentation skills and has helped me evolve and relax while presenting, training or when working with my peers. Overall, this training has enabled me to grow in all aspects of my career and I have met great people along the way. I feel part of a larger network"*

Finally, a first year Lead Teacher states:

> *"As I reflect on my experience as a first year Lead Teacher I am amazed at the growth that I feel at a personal level as well as at a professional level. Being involved as a VIPS Lead Teacher opened my eyes as to the importance of the lesson study process. This process has enabled me to work closely with the other teachers at my grade level to become more collaborative and reflective in our teaching. I feel much more confident in all of my teaching as a result of this experience."*

For students to reach the goals to which the standards require and that school districts wish to attain, teacher learning and change are essential. This requires a different method of addressing the challenge of systemic reform. This type of systemic reform required must address changes in people within the system because people influence the structures, procedures, and the policies that guide teaching and learning. The development of a strong cadre of teacher leaders at the both the system and school level are an essential element in this process of change. The importance of teacher leadership to the change process should not be overlooked as school districts plan and implement science reform initiatives.

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