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AUTHOR Nesbit, Catherine R.; DiBiase, Warren J.; Miller, Anne-Courtney S.; Wallace, Josephine D.

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ABSTRACT

Reform in science education not only focuses on student learning but also on the changing role that teachers play in the reform movement. This change involves teachers assuming new leadership roles in both their classrooms and schools. The leadership role involves teachers bringing about school-wide change by involving their school colleagues in the decision-making process and empowering them to be the initiators, instead of the receivers of change. Professional development is integral in the preparation of teacher leaders involved in change. The FIRST Project was a statewide professional development program designed to develop a cadre of elementary science and mathematics teacher leaders in North Carolina. This chapter describes the elements of the 15 professional development programs that the teacher leaders found helpful when implementing their new leadership role in the school. The elements identified by the teacher leaders are embodied in three categories termed Knowledge of Content and Pedagogy, Delivery of Professional Development, and Leadership Skill Development. (Contains 35 references.) (Author/MVL)

12 In Their Own Words: What Science and Mathematics Teacher Leaders Say are Important Aspects of Professional Development

Catherine R. Nesbit
Warren J. DiBiase
Anne-Courtney S. Miller
Josephine D. Wallace
The University of North Carolina at Charlotte

Reform in science education not only focuses on student learning but also on the changing role that teachers play in the reform movement. This change involves teachers assuming new leadership roles in both their classrooms and schools. The leadership role involves teachers bringing about school-wide change by involving their school colleagues in the decision-making process and empowering them to be the initiators, instead of the receivers of change. Professional development is integral in the preparation of teacher leaders involved in change. The FIRST Project was a statewide professional development program designed to develop a cadre of elementary science and mathematics teacher leaders in North Carolina. This chapter describes the elements of the 15 professional development programs that the teacher leaders found helpful when implementing their new leadership role in the school. The elements identified by the teacher leaders are embodied in three categories termed Knowledge of Content and Pedagogy, Delivery of Professional Development, and Leadership Skill Development

National groups including American Association for the Advancement of Science (AAAS), (1989, 1993), National Council of Teachers of Mathematics (NCTM), (1991), National Science Teachers Association (NSTA), (1992, 1993), and National Research Council (NRC), (1996) have called for reform in science and mathematics education. At the same time, national education reform reports (Carnegie Commission on Teaching as a Profession, 1986; Holmes Group, 1986) have recommended changes in teachers' roles. Thus, the reform movement not only focuses on student learning but also on the changing role that teachers play in the reform movement. The change in teachers' roles involves assuming new leadership. As

leaders, teachers facilitate a change in both their classrooms and schools. Pellicer and Anderson (1995) argue that no school-wide change will occur unless teachers assume a variety of leadership responsibilities. These new responsibilities have teachers bringing about school-wide change by involving their school colleagues in the decision-making process and empowering them to be the initiators, instead of the receivers of change.

Professional Development for Teacher Leaders

Professional development is integral in the preparation of teacher leaders. These programs must provide learning experiences that help deepen teachers' understanding of science content and pedagogy (Loucks-Horsley, Hewson, Love, & Stiles, 1998). In addition, these programs must provide opportunities for teachers to develop their leadership skills (Miller, Wallace, DiBiase, & Nesbit, 1999). As such, teacher leaders will be equipped with the requisite skills and knowledge to initiate and facilitate reform that best suits the culture of their respective schools. Research on adult learning and development shows that a passive, one-size-fits-all approach to professional development will not effect school-wide change (Howe & Stubbs, 1997). If the end result of professional development is to help teachers become agents for school-wide reform in science and mathematics education, then designing professional programs different from those which have been employed in the past is crucial. All too often, approaches to professional development employ a passive format in which reforms are dictated by state and national authorities. What is needed for the present and the future however, are professional development experiences designed to prepare teachers to assume a leadership role and effect school-wide change. One such approach to professional development was implemented in North Carolina. After participation in the North Carolina initiative (Franklin, 1993), as part of the project evaluation, the teacher leaders identified the aspects of professional development that helped them to assume a leadership role.

North Carolina's Lead Teacher Initiative

The North Carolina Mathematics and Science Education Network (MSEN) sponsored a statewide professional development program (Franklin, 1993) designed to develop a cadre of elementary teacher leaders in science and mathematics. A teacher leader was a classroom teacher who volunteered or was selected to participate in a professional

development experience and then return to school and work with colleagues to effect change. The responsibilities assumed by the teacher leaders were in addition to their regular teaching schedule (Miller, Wallace, & Nesbit, 1997). The initiative used teams of two full time teachers and their school principal, who agreed to collaborate with their school colleagues to bring about improvement in mathematics and science instruction. The project was funded by the U. S. Department of Education Fund for the Improvement and Reform of Schools and Teaching (FIRST).

The FIRST Project (Franklin, 1993) prepared the teams to assume a leadership role at the local school level through learning experiences designed to strengthen their science and mathematics content, pedagogical knowledge, and leadership abilities. Fifteen professional development programs were designed and implemented at eight university sites over a three-year period. Three hundred and fifty-four teachers from 180 schools were involved in the two-year professional development programs, which included pre-assessment sessions, a summer institute, academic year follow-up sessions and a culminating workshop held the following summer. The selection of teacher leaders by building principals was based on the following criteria: teachers who were well grounded in mathematics and science content background, teachers who were recognized as excellent classroom teachers, and teachers who demonstrated good communication skills. However, many of the participating teachers did not meet the desired criteria. In some schools, teachers volunteered and in others they were designated. As such, the teacher leaders were only slightly better prepared than other teachers at their school in that they reported taking more content related coursework and also were more often enrolled in advanced degree programs (Franklin, 1993).

The 15 professional development programs all included four similar core elements: curriculum, instruction, assessment, and administrative support. Each program was based on the school's Needs Assessment (Franklin, 1990) and therefore, each program had its own unique mix of the four core elements that supported content and leadership development. However, all programs devoted at least 60% of the time to content and pedagogy and from 18% to 40% to leadership (Miller et al., 1997). Programs also varied in the type of activities and the type of presenters involved with the professional development.

An important question emerged during the project's implementation. What aspects of the professional development programs would the teacher leaders find helped them in implementing their new leadership role in the school? Analyses of what the teacher leaders said provided the answer to this question (Nesbit, Wallace, Miller, & DiBiase, 1998).

Qualitative and quantitative data were gathered from 288 of the 354 teacher leaders who began the project. Data from the teacher leaders were collected from three different sources: two written assessments completed by all participants and structured individual interviews with a randomly selected subgroup of 30 teacher leaders from 15 different schools. The written post-program assessment included Likert scale items and open-ended questions (Franklin, 1993). In the Likert scale items, the teachers were asked to rate the importance of 17 different aspects of the program in helping them carry out the project at their schools. The open-ended assessment consisted of two questions: What aspects of the project helped the most? and What would have helped more? The Structured Interview Protocol (MSEN, 1993) included 50 questions, seven of which focused on the teacher leaders' perceptions of the 15 professional development programs. "Think of some specific things in this project that have helped you most in your role as a teacher leader and tell me about them" is an example of the type of question posed.

What Teacher Leaders Had to Say

Three broad categories emerged during the analysis of the data gathered from the teacher leaders (Franklin, 1993; Nesbit et al., 1998). The categories were termed: (1) Knowledge of Content and Pedagogy, (2) Delivery of Professional Development, and (3) Leadership Skill Development. Leadership Skill Development included subcategories identified in a previous study (Miller et al., 1997): Knowledge of Leadership Content, and Planning and Practice of Leadership Skills. The three major categories involved a number of factors that varied by programs in the amount of time they were used or implemented. Figure 1 depicts the relationship of these three overlapping categories and factors. In this chapter, we discuss the categories and related factors.

Knowledge of Content and Pedagogy

The FIRST Project involved teacher leaders in activities that included subject matter knowledge and teaching strategies. Knowledge

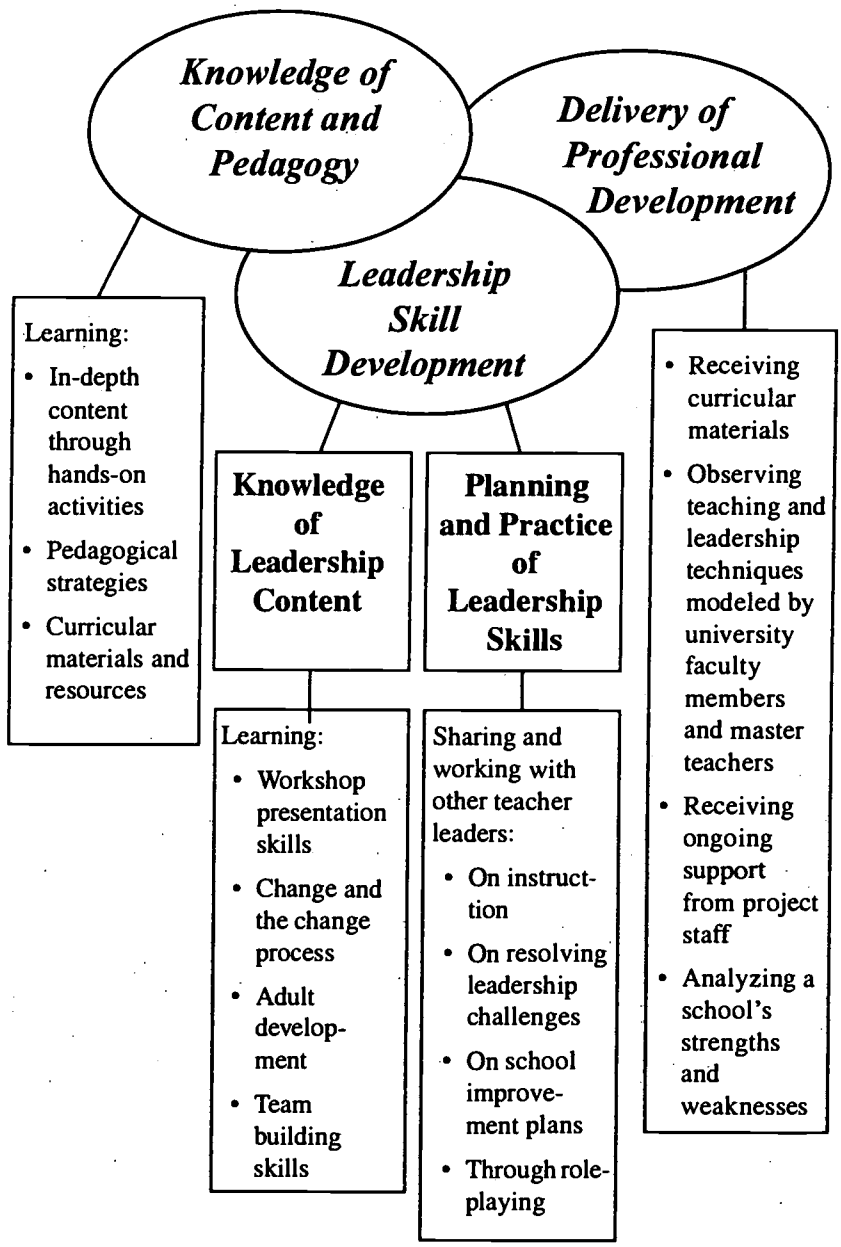

Figure 1. Important Factors in Professional Development According to Teacher Leaders

of Content and Pedagogy is a category within the professional development experience that includes "presentations directly related to science, mathematics, or both" (Miller et al., 1997, p. 10). Topics and activities related to content and pedagogy and those that integrate content and pedagogy were assigned to this category, which emerged as the most important one to the teachers with 61% of the total responses. The category of Knowledge of Content and Pedagogy includes learning in-depth content through hands-on activities, learning pedagogical strategies, and learning about curricular materials and resources.

Learning in-depth content knowledge meant that teachers needed more than a cursory introduction to a concept in order to understand it. Further, many teachers talked about needing to know developmentally appropriate concepts and student misconceptions about these concepts. One teacher said:

> *It made me feel confident about science, where I hadn't before, and it made me feel like I had the background that I needed and was able to do it. Teachers need to have more knowledge in science and math. Things change. What I learned in college is far from adequate and I have a pretty good knowledge of science. New teachers are not any better prepared. Too much misinformation is shared.*

Learning through hands-on activities helped teacher leaders understand the subject matter. These learning experiences helped the teacher leaders bring their knowledge back to colleagues at their respective schools.

> *I would say almost even more than what we learned, the hands-on lessons were very impressive. That just stood out. I enjoyed it; doing everything and working through the whole process makes you take it back and do it yourself. Just all the physical science and the biological science,* [I] *remember a lot of those activities.... The nature walks, the actual hands-on, not just sitting there listening to lectures but* [I] *really got in there and did everything with them.*

Learning pedagogical strategies implied that content should not be taught in isolation. Teacher leaders identified items on the post-program assessment that indicated they wanted content integrated with pedagogical strategies. In other words, as they learned the content, the

teacher leaders also needed to learn effective teaching strategies. A teacher said:

> *Through this math workshop, I began to understand and learned a little more about how teachers taught fractions, or how they teach children to work with decimal points and things. These are things that I really never thought about, but as a lead teacher, you have to learn more about it, because you are responsible for giving ideas to those teachers in other grades besides just the ones that you're comfortable with.... Examples of how to teach certain hard-to-teach concepts.*

Learning about curricular materials and resources provided teachers with information about the many resources available to them. Not only did they find out about these resources, but they also found out how to order and obtain the resources for their schools. Teachers also noted the benefits of learning about materials management.

> *I guess the resources that we gained were most beneficial—people that we can contact, science programs that we saw and were exposed to, the technology we were exposed to. To know that there is so much out there kind of shook us awake. We had been just dreaming for years, and we didn't know how to dream. Learning what types of manipulatives are available and how to use them in order to teach better with children understanding.*

Delivery of Professional Development

Teacher leaders identified certain aspects of Delivery of Professional Development as important factors for them. Delivery of Professional Development is defined as the manner in which staff development is carried out and includes both who does the instruction and how it is presented (Miller et al., 1997). Of all the responses given, 20% dealt with this category. Delivery of Professional Development includes the following four aspects: receiving curricular materials and resources, observing teaching and leadership techniques modeled by university faculty and master teachers, receiving on-going support from project staff, and analyzing a school's strengths and weaknesses.

Receiving curricular materials and resources was identified as important in supplementing classroom materials for science and mathematics teaching. The project provided many of these materials to the teachers and in addition, the schools contributed funding

for hands-on materials. The resources included calculators, videos, software, print materials, magnifying lenses, and other low cost items. One teacher said, "giving teacher leaders the resources they need to have an up-to-date program...having a notebook full of ideas and people to contact in coming years."

Observing teaching and leadership techniques modeled by university faculty and master teachers was valued by the teacher leaders. A master teacher in this project was a classroom teacher who was recognized for their instructional skills by serving as a co-instructor with university faculty. The presenters showed teachers how to teach and lead others by their own presentations. Comments such as the following verify teachers' interest in modeling:

> *The demonstrations by the faculty of the different hands-on activities helped me the most; being able to participate in these demonstrations enabled me to gain confidence in presenting it to others. Actually seeing the experiments being performed and doing our own experiments. Also watching our teachers when they explained to us how to do different experiments.*

There was praise for both university faculty and master teachers. However, there was more motivation for listening to master teachers. This is illustrated in the following teacher's quote.

> *It's easier to understand when there is someone from the classroom that has actually done this and they can tell you, this is how it works. Teachers who were experienced, hands-on practitioners were teaching.* [This was] *one of the most helpful aspects. I knew they were not just theorizing about what might work in a classroom.*

Receiving on-going support from project staff throughout the two year professional development program was a critical element for the teacher leaders. The professional development programs were sequenced to provide on-going support throughout the academic year. Helpful aspects according to one teacher were:

> *Support of project staff in our school endeavors. The folks gave us all direction to follow through with school goals. It was a part of each session. The follow-up sessions because they kept you in touch with what was going on and they made you think continuously about math and science.*

In addition to the follow-up sessions, some project staff were in contact with the teacher leaders through telephone conversations and school site visits. One teacher leader spoke about this type of support as being helpful. Knowing "that I may contact the resident experts at [a local university] when I get stumped. I was helped during the school year with activities on probability that added a lot to my presentation of that concept."

Analyzing a school's strengths and weaknesses provided feedback for designing the professional development programs. The professional development programs were built on the needs of the individual schools. Each teacher and administrator completed a Needs Assessment, which was then analyzed by the teacher leaders (Franklin, 1990; Penta, Mitchell, & Franklin, 1993). With the Needs Assessment results in mind, the teacher leaders and administrators drew up a School Improvement Plan for each school with input from the school faculty. One teacher leader said that "The School Plan was most helpful in that we recognized weaknesses and began to build on them....evaluating our school's needs...seeing our weaknesses and working on them to meet our goals."

Leadership Skill Development

Teacher leaders identified components categorized as Leadership Skill Development as being important in their professional development program (Franklin, 1993). Nineteen percent of the teachers' responses fell into this category which included two subcategories: Knowledge of Leadership Content and Planning and Practice of Leadership Skills.

Knowledge of Leadership Content involved formal presentations of leadership skills (Miller et al., 1997). This subcategory included learning workshop presentation skills, learning about change and the change process, learning about adult development, and learning team building skills.

Learning workshop presentation skills enhanced the teacher leaders' ability to work with others at their school. One teacher said:

> *How to teach a workshop, how to make it interesting, how to plan for the comfort of the other teachers as far as just physical things because I had never done a workshop before that was very helpful in being a lead teacher.*

Learning about change and the change process was particularly beneficial as teacher leaders went back to their schools and began

introducing innovations to their colleagues. As is recounted in the following quote, the teacher leaders went to their colleagues filled with enthusiasm and were often met with far less enthusiasm. "I think any kind of change takes time and I think if you try to go in there like a gang buster and say, this is the way its going to be, you're going to fail."

Learning about adult development is vital as working with adults differs from working with students in the classroom. As such, learning about adult development is an important aspect of a professional development experience for teacher leaders. The teacher leaders reported that this information helped them get their school faculty "on board" when changes in science and mathematics instruction were introduced. The teacher leaders recognized the need to be aware of other teachers' perspectives when supporting them during the change process. The teacher leaders also discovered that experienced teachers were in a very different place compared to beginning teachers. One lead teacher expressed this by saying that you, "have to be a wonderful listener first before you can be a leader to find out where people are coming from...learning about adults' learning process." This was one teacher's story:

> *At our school, I think one of the things that has changed for me, particularly as a lead teacher, is that now I've become more of a counselor to the teachers with experience. Beginning teachers are willing to try anything. So I have to encourage them [the veteran teachers] by almost providing the lesson. I've done that for some teachers who've taught as long as I have.*

Learning team building skills assisted teacher leaders as they involved their colleagues in taking ownership in developing and sustaining the innovations at their schools. These teacher leaders saw the importance of getting their teachers involved in the decision-making process in order for change to take place. A shift in perspective took place as they saw their role changing. One teacher expressed it this way:

> *When I first thought about it [the role of lead teacher], I thought that all I'd have to do was come down here [to the professional development program] and get the information and just give it to them [teachers at my school] and let them do whatever they wanted to. But I see now that I need to get*

more of my faculty involved...showing me how to get the 'outs to be in.'

Another teacher added, "Helping me to be more confident of myself so that I could be a model and encourage others. The team building and 'bringing outs in' was very beneficial."

Planning and Practice of Leadership Skills included the opportunity to develop and use leadership skills (Miller et al., 1997). This subcategory included sharing and working with other teacher leaders on instruction, on resolving leadership challenges, on School Improvement Plans, and through role-playing.

Sharing and working with teacher leaders on instruction provided opportunities for exchanging expertise. Often the teacher leaders either taught or co-taught the learning sessions. One teacher's comment reveals her opinion about the helpfulness of input from other teachers.

I think one of the plusses in it was how we were able to share with teachers from other classrooms. You see, if I'm doing this and you're doing that and somebody else is doing another thing and if we can sort of get together and share, maybe something that I'm doing can help you and maybe something that you're doing can help me.

Sharing and working with other teacher leaders on resolving leadership challenges included reflection and problem solving. Teachers faced a number of challenges as they implemented the project at their respective schools. For example, the resistant teacher who refused to get "on board" confronted many of them. By having the opportunity to share both their expertise as well as the successful experiences of other teachers, the teacher leaders were able to solve many school-based problems. Teacher leaders expressed support for the sharing theme when they said:

Sharing experiences was most beneficial. At the time we first went to [the follow-up sessions], *we were concerned because our staff was not pulling together for the* [school-wide] *workshop. They* [the other teacher leaders] *gave us some good suggestions, like modeling these activities, having the workshop on a regular school day, and calling in volunteers.* [It was] *great because our whole staff participated, all of our teachers participated* [in the workshop].

Having the time to talk out the problems you're having, and are you having this at your school? Well, how could we do this? How could we go over this challenge? I think that was a great strength.

Sharing and working with other teacher leaders on School Improvement Plans gave structure for the teachers to share and support each other during the professional development program as well as during the implementation phase in the school. Leadership teams were normally comprised of two teachers from each school, one teacher from the primary grades and the other from the intermediate grades. One of the projects that the leadership team worked on together was developing, presenting, revising and implementing the School Improvement Plans. Many teacher leaders took their School Improvement Plan back to school and presented it to the teachers in order to solicit support. One leader spoke about the support she received from her fellow lead teacher as she presented the School Improvement Plan.

When the other lead teacher came for observations with me that helped me tune in on what I needed to do as far as presentations because several of her observations were of me presenting to the faculty...having a support from someone at school...developing a School Improvement Plan.

Sharing and working with other lead teachers through role playing gave teachers the opportunity to plan and practice leadership skills and lesson presentations.

The person who did our leadership session was tremendous. She knew exactly how to get us fired up, and showed us how to go about improving our leadership skills. And the other lead teacher was a tremendous support and we practiced leadership with each other.

Another teacher said:

The biggest thing that I learned is that I could get up in front of a group and present a lesson and I can do it without dying, realizing that, yes, I do have some lead teacher capacity here.

Conclusions and Implications

The teacher leaders identified a number of varied learning experiences that were needed to prepare them for a leadership role and to help them to effect school-wide change. The elements identified by the teacher leaders are embodied in the categories termed Knowledge of Content and Pedagogy, Delivery of Professional Development, and Leadership Skill Development. Each category is comprised of a number of elements which teachers said were important in preparing them for their leadership role.

Teacher leaders' comments reflected on the value of including Knowledge of Content and Pedagogy in the professional development experience. The elements included in the Knowledge of Content and Pedagogy category are well cited in the literature. A report by the U.S. Department of Education (Sivertsen, 1992) notes that "teachers need to know the discipline, to understand the key ideas, and their relationship to each other" (p. 21). Knowledge of the discipline is vital for effective instruction (Loucks-Horsley et al., 1998). However, content knowledge alone is not enough. Time must also be allotted for the development of pedagogical content knowledge. According to Schulman (1987), pedagogical content knowledge includes an understanding of the content, knowledge of students' misconceptions, developmentally appropriate concepts, and instructional strategies that will help students learn.

In addition to Knowledge of Content and Pedagogy, the teacher leaders identified a number of helpful aspects related to Delivery of Professional Development. The elements in this category are also supported in the literature. Zinn (1997) reports the benefits gleaned from leadership modeling. The NRC (1996) also notes the importance of demonstration and modeling techniques. In addition, both the NRC (1996) and Loucks-Horsley (1998) recognize that receiving instructional materials plays an important role in promoting teacher change. Furthermore, knowledge of a school's climate, the principal's commitment to reform, and the district's priorities all play a role in how well a newly-defined teacher leader can help bring about change (Fullen, 1993). Using a needs assessment at the beginning stages of the professional development experience helps the emerging teacher leader to address both the needs and goals of their school and district.

Another important factor the teacher leaders identified was receiving support from project staff. Researchers such as Bennis

(1989), Garmston (1988), Leithwood (1992), and Pellicer and Anderson (1995) encourage including a way to ensure that the teacher leaders have support as decision-makers. Lieberman (1995) and Darling-Hammond (1995) report the need to include support from key school system personnel. The active involvement of principals is recognized by Hanson, Thompson, and Zinn, (1993), Lieberman (1988), and Pellicer and Anderson (1995). Other researchers (Graebill & Phillips, 1990; Loucks-Horsley, 1992; Bolman & Deal, 1994; Bredeson, 1995; Wasley 1991) describe the benefits realized from supportive behavior from other teachers.

The teacher leaders also identified aspects categorized as Leadership Skill Development as important in their professional development experience. Leadership Skill Development includes both Knowledge of Leadership Content and Planning and Practice of Leadership Skills. Both aspects are essential ingredients of a professional development experience (Nesbit et al., 1998). There are very few studies that specifically include elements related to Knowledge of Leadership Content. However, Zinn (1993) notes that teaching presentation skills is a key aspect of professional development. More research is needed on the role played by Knowledge of Leadership Content in the development of teacher leaders.

Many professional development programs in science and mathematics provide subject content and pedagogy as well as aspects related to the delivery of professional development. However, these programs often leave out the development of leadership skills. Developers and facilitators of professional development for teacher leaders would do well to include time for the participants to share and work with others on instruction, role-playing and resolving leadership challenges.

Key Findings

As previously noted, attending to key concepts of the subject and teaching strategies as well as certain aspects of the design of the professional development program are important experiences for teacher leaders. However, a focus on Leadership Skill Development where teachers learn how to work with other teachers to bring about change is ofen neglected and is necessary because in assuming a leadership role teachers are often entering a new arena. There are excellent teachers of children who have never been exposed to the

essential knowledge nor practiced the necessary skills needed to work with and lead other adults, specifically their peers. Teacher leaders cited certain elements of Leadership Skill Development, such as workshop presentation skills and working with other teachers on resolving leadership challenges, as important ingredients to be included in professional development programs. This unique category, Leadership Skill Development, has two subcategories, Knowledge of Leadership Content and Leadership Planning and Practice. Although teacher leaders acknowledge the importance of the inclusion of elements from both subcategories, they indicate of the two subcategories the specific elements of Leadership Planning and Practice were most crucial for them. In other words, what teacher leaders are saying is that once they receive a leadership knowledge base, they need opportunities to practice what they have learned through role playing and demonstration lessons with other teacher leaders.

In summary, the acquisition of new leadership skills is fostered by a number of experiences: the formal presentation of leadership topics, time for planning and adapting the knowledge to their own school setting and finally, practicing the skills the teachers have learned. Throughout such learning experiences, teachers report that they benefit from discussing and sharing with other teacher leaders, processing the information and receiving feedback from others as they practice their new skills.

These elements are cited by teacher leaders as being important ingredients to prepare them for their leadership roles in their schools. Having acquired and practiced these leadership skills, teacher leaders will be able to engage their school faculty in considering new ideas and collaboratively working to develop and implement school change that fits the needs of their school.

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