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Developing Teacher Leaders in Science: Catalysts for Improved Science Teaching and Student Learning

The Reaching for Excellence in Middle and High School Science Teaching and Learning Partnership Project at East Tennessee State University has a long history in the development of teacher leaders. This article describes the professional development model, the challenges addressed, and the impact on both teacher and student learning.

The science education reforms in our recent educational history brought to center stage the important role of professional development. Recognizing that science teachers represent the major link between the curriculum and student learning, expert practitioners, researchers, and policy makers emphasize professional development as an essential mechanism for deepening teachers' content knowledge and developing their teaching practices. Professional development has traditionally focused on the need to enhance and enrich teachers' content knowledge. Subsequent to the release of the National Science Education Standards (National Research Council, 1996), an increased emphasis on pedagogical knowledge has found a prominence in the role of professional development. Building on teachers' renewed grasp of content knowledge and inquiry-based pedagogy, an expanding view of professional development has incorporated a leadership component in which educators are recognizing the need for science teachers to become leaders within their own school and school district to advance reform efforts and impact student learning (Guskey, 2003; National Staff Development Council, 2001; Sparks, 2004). This role of professional development promotes job-embedded, sustained opportunities for professional growth and systemic change (Loucks-Horsley, Love, Stiles, Mundry, & Henson, 2003).

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Working with thousands of teachers over a decade, Katzenmeyer & Moller (1996) elaborated on the important role of teacher leaders and the important role teachers must exert if meaningful change is to be made and sustained in the school. They define teacher leaders as those "who lead within and beyond the classroom, influence others toward improved educational practice, and identify with and contribute to a community of teacher leaders" (p.6). Teacher leaders build the school's capacity to improve. According to Fullan (2007), "the litmus test of all leadership is whether it mobilizes people's commitment and energy into actions designed to improve things" (p.1). The essential role of leadership, therefore, is the ability to work and collaborate with others. For example, teacher leaders are able to cultivate and encourage colleagues to support new ideas, support the growth of others, and build consensus among diverse groups.

The challenge for teachers and principles is to promote and design professional development programs that encourage and promote effective teaching practices and increased student learning. In recent years, a body of research has emerged on characteristics of effective professional development, teacher learning, and teacher change. The research summarized by Hargreaves and Fullan, (1992); Hawley and Valli, (1999); Leiberman,(1996); U.S. Department of Education, (1999); Loucks-Horsley, Hewson, Love, and Stiles, (1998); Sparks and Loucks-Horsley, (1990); Stiles, Loucks-Horsley, and Hewson, (1996); Rhoton and Bowers, (2001); Rhoton, (2001); Rhoton and Wojnowski, (2006) identifies such approaches.

- Professional development addresses issues of concern recognized by teachers themselves. One-size-fits-all professional development does not, in fact, meet the needs of all teachers. Teachers at different stages in their teaching career will require professional development to meet their specific needs.
- Professional development is connected to classroom practices. It should address issues and immediate concerns relevant to the classroom, such as teaching practices and working with different ability and motivation groups.
- Professional development includes sustained support and takes place over an extended period of time. Lasting change usually occurs only when teachers are given the sufficient time, resources, and training to carry out the innovation.
- Professional development helps teachers learn science content in new ways. These experiences allow teachers to genuinely address change and renewal and reach beyond the "make and take" workshop and the "idea swap" session to more global, theoretical conversations that focus on teachers' understanding of the processes of science teaching and learning and of the students they teach.
- Professional development challenges pedagogical beliefs and practices. Teacher perceptions about student learning, confidence in subject matter understanding, and pedagogical beliefs will affect student learning.
- Professional development promotes incremental change. Although large-scale change may be needed, incremental change allows teachers to retain existing effective practices.
- Professional development encourages collaboration. Teachers consistently rank professional development activities that take place close to the working environment as the most important. Change usually occurs in small pockets within the school.

When school leaders implement the preceding approaches to build the professional development infrastructure, the school's culture and climate will be more conducive to practices that allow teachers to gain enhanced science content knowledge and pedagogical skills, interact with their professional peers, enhance student learning, and meet school-wide goals. However, school administrators must commit to creating a professional development climate that nurtures lively learning environments for communities of teachers.

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Even though these prominent characteristics and particular approaches of effective professional development, as well as others, are quite visible in the literature, very few systematic research studies have been conducted on the extent to which these approaches contribute to better teaching and improved student learning (see, in particular, Guskey, 2003). Some recent studies are beginning to show, however, along with the experiences and wisdom of expert practitioners, that professional development that incorporates all or most of these approaches can have substantial, positive influence on teachers' practices and student achievement (Hildreth & Rutherford, 2004; Rhoton & Bowers 2001a, 2001b; Loucks-Horsley, et al., 1998; U.S. Department of Education, 1999).

Professional development reform initiatives have directed the largest resource investment to teachers' professional development; however, researchers and expert professional developers have seen much of this investment as supporting ineffective practices. Although educators may recognize the importance of new training models for improving science teaching practices, professional development strategies remain largely unchanged, detached from the realities of the classroom, and ineffective for promoting long-term change (Elmore et al., 1996; Stiles et al., 1996). Even as we go deeper into the 21st century, too much of what is promoted as professional development is dominated by stand-alone workshops and short after-school meetings. Moreover, teachers have typically perceived their professional development programs as ineffective, poorly planned, and lacking in relevance to their instructional practices (Sparks & Loucks-Horsley, 1990).

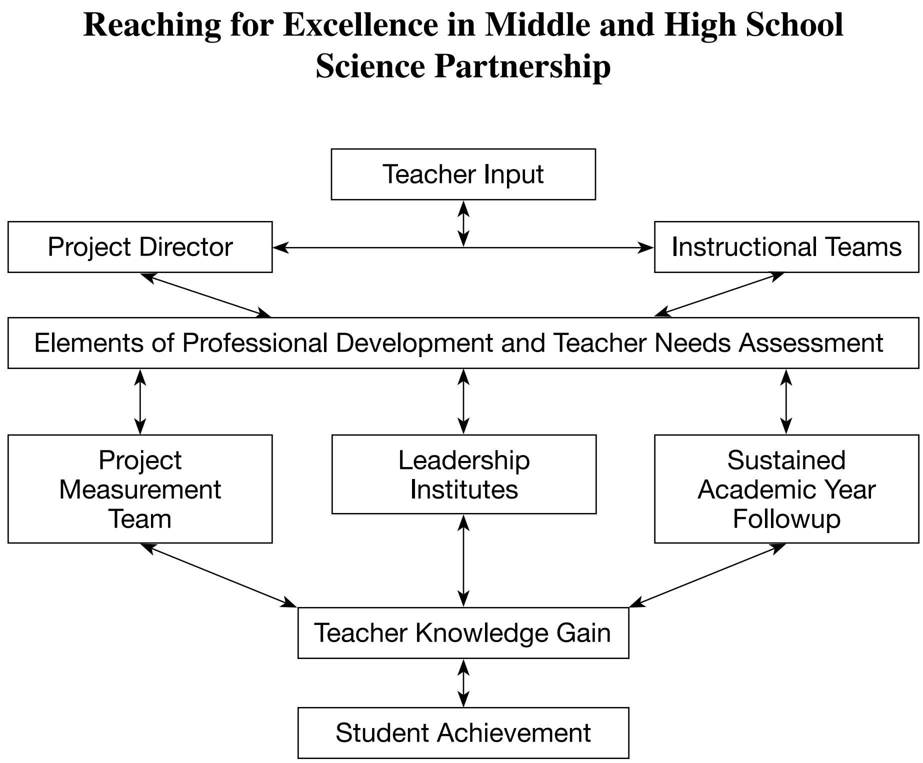
The Model Implemented

What does an effective professional development program look like when it captures the elements of effective professional development and supports an ongoing, sustained approach for science teaching and learning? One thing we have learned is that short-term, one-shot workshops do not greatly enhance teachers' learning or the transfer of that learning into the teachers' classrooms. The East Tennessee State University Science Partnership (ETSUSP) provides an example of one way in which an ongoing, sustained professional development support system can assist elementary and high school science teachers in improving their knowledge of science content and pedagogy and engage students in meaningful science learning experiences.

The ETSUSP has established a collaborative relationship, extending nearly two decades, with various funding agencies and local school districts in the Upper East Tennessee Educational Cooperative (UETEC) to develop and implement a model of professional development for science teachers.

The model (Figure 1) emerging from this 15-year partnership differs from traditional professional development paradigms. First, it offers sustained professional development support and teacher training throughout the academic year. Second, it requires the simultaneous development of instructional skills, administrative insights, and content expertise. Third, it is a grass roots effort involving teachers who implement and maintain the change.

Figure 1: ETSUSP professional development model



The model accommodates teams, composed of middle and high school science teachers, in the ETSU service area. Since the inception of the program, 750 teachers have been trained and more than 50 principals have been directly involved in the activities of the model. The ETSU model captures many of the principles of effective professional development as described in the professional development literature (see Table 1 for a comparison).

The model allows teachers to have control over their own needs. The following sections describe each component of the model and provide insights into ways in which the program is addressing professional development issues.

Content and Pedagogical Knowledge

Effective science teachers need a deep understanding of science content and pedagogy (Rhoton & Bowers, 2001a). Researchers and expert practitioners agree that content knowledge can have a positive influence on student achievement, especially in secondary science (Blair 2000; Whitehurst, 2002).

To build opportunities for participants to gain enhanced content and pedagogical knowledge, the ETSU model makes available summer science leadership institutes (Summer Institutes) for elementary and high school science teacher participants. The institutes run for 12 days each

Table 1: Principles of effective professional development for science teachers

Cited by various sources	ETSU Framework and Model
Focus on content knowledge, pedagogy, and leadership	Science institutes for content, pedagogy and leadership
Focus on student learning	Analysis of teaching and learning
Collective participation	Teacher teams
Links to high standards	State and national standards
Opportunities for teachers to be engaged in leadership roles	Teachers as mentors
Bringing together various stakeholders	Project management team
School-based and job embedded	School-site professional development
Use of date to inform professional development decisions	Analysis of student classroom data
Monitoring and assessing	Assessment each year

summer and are taught by ETSU science faculty and science educators. Institutes focus on both science content (inquiry in science) and inquiry in teaching and learning. Participants engage in a variety of science investigations in the areas of biology, chemistry, and physics, with topics for investigations driven by the participants, student data, and local and state science standards. Investigations and institute activities are presented in the context of how the teacher participants can implement them effectively in their own classrooms.

In addition to learning science content, participants explore questions and ideas about their students' learning, their teaching, and their curricular approaches. These conversations prepare the participants for examining meaningful ways to connect their students' understanding with accepted practices of teaching and learning, thereby providing for a seamless integration of content and scientific ideas with knowledge of student learning and pedagogical practices.

Each participant in the project receives the science supplies and equipment necessary for his or her science curriculum, graduate credit, and a stipend for participating in the project.

After participants return to their schools to implement the science program, university science faculty provide ongoing support for them by visiting them in their schools during the academic year. During these visits university faculty can gather information from teachers and principals as they implement the professional development model as well as support teachers in their classroom environment. Program participants work with their peers by leading monthly science in-service training sessions, observing peer teachers, teaching model science lessons, and assisting their peers in analyzing and selecting instructional materials for their classrooms.

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Administrators' Roles in Science Education

In our lengthy professional development work, we have learned that the school administrator plays an important role in maintaining an effective school science program. The instructional management role of the principal is complex, shaped and constrained by many issues. Current reform initiatives in science education, moreover, compel the school administrator to think of new ways to accomplish standards-based reform in his or her school. For example, there are matters of teacher time, structural arrangements, cultural norms, and teacher learning, all of which affect student learning, either directly or indirectly.

The detached manner in which professional development for science teachers is typically handled compounds the problem. Programs may be coordinated from the district office and conducted during after-school hours or during summer months, perhaps on a local college campus or other off-school location. In many cases, principals may not even be aware of the type of in-service training their teachers have received. Similarly, teachers are seldom aware of their principals' academic backgrounds or preparation in specific subject areas. Consequently, teachers and principals alike may despair of improving science instruction and never realize their mutual interest or the others' resourcefulness in developing constructive programs. Clearly, they need effective channels of communication to ensure the combination of administrative and instructional insights and cooperation needed for reform of science teaching.

The teaching and learning of science are generally perceived to take place in the context of an individual teacher working with a group of students in an individual classroom, but teaching is not a solitary activity. Many dynamics affect the teaching and learning of science in a school or even in a single classroom. Having a clear set of standards for classroom practice is an important part of the equation, but real, long-lasting change calls for the principal playing an active role. The principal who recognizes the crucial importance of school-and district-based initiatives can use his or her influence, power, and authority to help shape critical approaches to science education reform efforts (see Figure 2). Changes in educational practices rarely happen quickly, and pervasive and permanent changes rarely come from without. Successful programs involve many participants—including teachers, science coordinators, and administrators—playing different roles (NRC, 1996).

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Project Management Team

The project director of the ETSU summer institutes works closely with each layer of the project and serves as a vital link among the ETSU science faculty, local education agencies (LEAs), and the Project Management Team (PMT). In addition to the project director, the PMT consists of central office curriculum directors with decision-making authority, school principals, university science professors, and middle and high school science teachers, all of whom represent participating school districts. For nine months before each of the summer leadership institutes, members of the PMT meet quarterly to establish an agenda based on the needs assessment described below. The PMT designs the summer institutes and follow-up academic year professional development activities for the subsequent year. The PMT meets throughout the academic year to realize the project goals and build leadership capacity.

To examine student learning more closely and to collect evidence to inform the professional development process, institute participants, working in conjunction with the PMT, evaluate science lessons from their classrooms, explored questions and concerns about their students' learning and analyzed data from classroom assessment and end-of-course exams. This data analysis assisted the PMT and the teacher participants in identifying, prioritizing, planning, organizing, and making resource allocations for the professional development activities during the summer leadership institutes and the professional development activities during the academic year. As the ETSU professional model has matured, this data analysis has become increasingly important in informing both the professional development process and the teaching process.

Science Standards

According to the National Science Education Standards, "Learning science is something that students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others" (NRC 1996, p. 20). This approach is consistent with the East Tennessee State University Science Partnership Model, which considers students as active constructors, rather than passive receivers, of knowledge. Accordingly, students who bring their own view of the world into the classroom are encouraged to be engaged in the learning process. An important role of the teacher in this process is to create learning environments that allow students to

Figure 2: Approaches principals can take to support science education reform

Creating an instructional organization and climate that are conducive to school-based initiatives and innovations

Creating a clear vision of effective science teaching and learning, as well as goals that reflect content knowledge

Providing high-quality instructional materials that support a coherent presentation of important science concepts

Providing the necessary resources to make materials available to all students

Supporting alternative assessment methods that more accurately measure students' deep understanding, not just short-term recall, of science ideas

Supporting ongoing and long-term professional development of science teachers

Maintaining class size appropriate for the science discipline

Hiring new science teachers who are well grounded in science content, the processes of science, and learning theory

Supporting environments in which all students can learn science in some meaningful way

Communicating to teachers about research and innovative practices outside the school district

Allowing teachers to visit innovative science programs both within and outside the school district

Encouraging grant proposal writing to supplement school resources

Pairing induction teachers (new science teachers) with compatible mentor teachers in an effort to provide neophytes with role models at the beginning of their teaching careers

engage in problem solving and higher-order thinking so they can integrate information and build on their own understanding of a particular topic or idea (Anderson, 1998).

School-Based and Job-Embedded

When university faculty make their monthly school site visits during the academic year, they can accomplish two other objectives. They can gather information from teachers and principals and provide support to participants as they implement the professional development model. During the visits, model lessons are presented. Visits, however, do not provide the continuous networking inherent in the professional development model. The project model gives participants an opportunity to develop a networking force for improving middle and high school science teaching and learning in the participants' schools.

The model allows for several kinds of communication and networking between and among teacher participants, both within the classroom and across the science program. Teacher participants play the role of sensitive facilitators to establish a climate in which team members build mutual trust and share what they have done in their classrooms. The professional development model allows for the teachers to network in the following ways:

- Members of the science department meet throughout the academic year to discuss and share information and classroom feedback. During this time science teachers may elect to discuss content and methodologies or reflect on classroom events of that week. These meetings are also used by participants to share information from the summer institute with their colleagues.
- Science teachers in targeted districts observe their colleagues teaching a science lesson using the methodologies and content gained during the summer institute. Teachers share feedback from the lessons and reflect on the appraisal of the lessons taught. These sessions provide insight, solutions to problems, and support and encouragement to one another. Teacher participants receive a great deal of input from one another and benefit form sharing of ideas from their own classroom experiences.
- Teacher participants lead professional development sessions for their colleagues during the school year.

- Principals in participating schools meet with science faculty in their schools to provide information and resources concerning science teaching and learning and to reduce barriers that impede effective science teaching.

Major rewards of the program have been the personal renewal of middle and high school science teachers' expertise in science content and pedagogical skills, increased focus on active student participation and student learning, frequent teacher-teacher and teacher-student interaction, and implementation of lessons that provide an accurate portrayal of disciplinary knowledge, nature, and structure.

An important outcome of this model has been continuous and ongoing professional development opportunities for participating school districts to track and document change systematically. These data revealed the following outcomes for participating schools:

- Planned and systematic scheduling of professional development in each participating school.
- Professional development that accommodates participants' needs and is embedded in practice.
- Networking of stakeholders (teachers, curriculum supervisors, principals, and university staff) who are responsible for student achievement in the training process.
- Sharing of support materials and resources in support of the science program.
- Using student data to inform professional development decisions.

Teacher Participant Evaluation Results

Teachers who were selected for the program and attended the twelve-day Summer Institutes in the summers of both 2006 and 2007 participated in a variety of assessments. The two cohorts of teachers participated in the Summer Institutes preceding implementing their newly learned skills in their classrooms during the 2006-07 and 2007-08 school years. Data from the 2007-08 cohort is reported first as the design included both ETSUSP and comparison groups. Teachers participating in the comparison group were selected who taught at the same schools as the ETSUSP treatment teachers, but did not participate in the project. The same number of non-participating teachers (total of 23) was selected from each school as the number participating. The comparison teachers were also volunteers as were the ETSUSP treatment teachers. Both ETSUSP and comparison teachers were given a 45-item multiple choice test based on the workshop content that was developed by the ETSUSP faculty who taught at the workshop. Previous analyses indicated the test was reliable and content valid. ETSUSP teachers were given the test on the first and last days of the summer workshop. The comparison teachers were given the pretest and twelve days later completed the posttest so the time interval was the same for both groups of teachers.

Three separate analyses were run. First, a number of descriptive statistics were computed. Second, an independent groups t-test was run on the pretest results between the ETSUSP (treatment) and comparison (non-ETSUSP) groups to determine if there were any knowledge differences between the two groups at the outset. Finally, a repeated measures ANOVA was run to determine if the treatment group demonstrated learning from the summer workshop at a rate different from the comparison group.

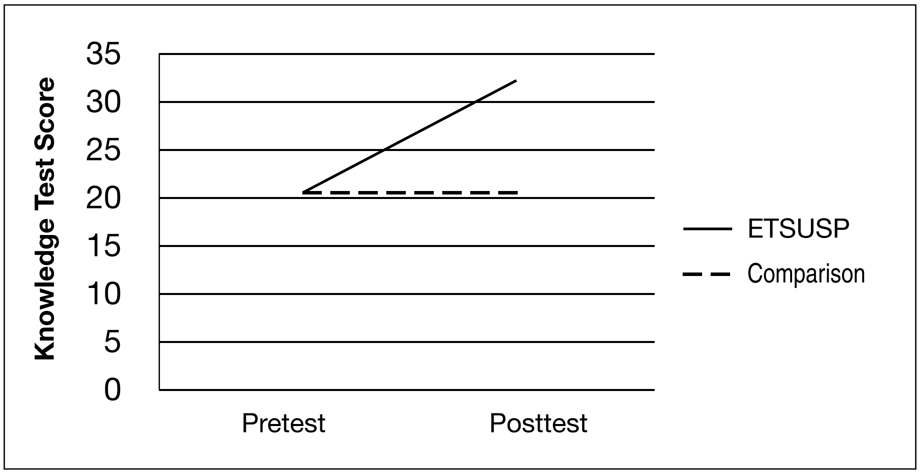
The pretest mean of the ETSUSP group was 20.04 (*SD* = 7.16) and the pretest mean of the comparison group was 20.35 (*SD* = 7.88). That difference was non-significant ($t(44) = -.14$, $p = .892$). The posttest mean of the ETSUSP group was 32.09 (*SD* = 5.48) and the posttest mean of the comparison group was 20.13 (*SD* = 8.07). However, the ETSUSP group's gain was significantly larger than that of the comparison group ($F(1, 44) = 87.8$, $p < .001$; partial eta square = .59) with an effect size gain in the ETSUSP group of 1.68. This is illustrated in Figure 3.

Since NCE scores are interval in nature, a repeated measures analysis of variance was used to analyze the results.

Thus, we can attribute the knowledge gain of the ETSUSP teachers to the workshop as those teachers demonstrated a major gain in knowledge while the comparison teachers did not show any gain at all.

The 25 teachers who participated in the 2006 ETSUSP Summer Institute also demonstrated statistically and practically significant knowledge gains, but there was not a comparison group. However, the 2006-07 cohort did participate in a number of follow-up activities during the fall of 2006. The pretest score mean for the 21 teachers who participated in the summer institute and had both pretest and posttests scores was 51.7 and the

Figure 3. Comparison of Pre and Post Teacher Knowledge of 2007-08 Cohort



posttest mean was 73.7. This gain was statistically significant ($t(20) = 15.64$, $p < .001$) with an effect size of 2.29. This means that the gains were statistically significant (less than one chance in 10,000 that this level of gain occurred by chance) and practically or meaningfully significant with the average gain being more than two standard deviations. Using any effect size rule of thumb, this increase is, from a practical standpoint, very meaningful. In addition, all 21 teachers showed impressive pre- to post-test gains. They ranged from 9.2 percentage points to 34.8 percentage points with an average of 20.0 percentage points.

As part of this follow-up, the teachers responded to a seven-item Likert-type Rating Scale Form (patterned after the summer Formative Rating Scale Form). It was administered to all 25 participating teachers during fall 2006 to determine their satisfaction with the follow-up and follow-along involvement of science faculty, the graduate assistant, and the project director. The participants were asked to respond to each of the items as they perceived the quality of assistance received by university personnel. The instrument was administered to the participants during the months of October, November, and December, 2006. The results of this survey are presented for each of the seven areas addressed by the questions.

- Ninety-two percent of the teachers indicated that the instructional materials used by the university personnel when visiting the classroom were effective. The other 8% indicated they were "somewhat effective."
- One hundred percent of the teachers agreed that the lesson plans taught by the university personnel were well-organized and geared to the level of their students.
- Ninety-six percent indicated that the university personnel shared appropriate science content background information and teaching strategies that were age appropriate for their students and the other 4% indicated they were "uncertain."
- Eighty-eight percent of the teachers agreed that the university personnel placed an emphasis on problem-solving and higher-order thinking skills rather than on exclusively factual information. The other 12% were uncertain.
- Eighty-four percent of the teachers agreed that the university personnel demonstrated how project materials and project resources could be presented or shared with peers. The other 16% were uncertain.
- One hundred percent of the teachers agreed that the instructional methods and procedures demonstrated by university personnel helped them in learning more effective methods of delivering their science curricula.
- One hundred percent of the teachers rated the overall effectiveness of university personnel visits to their classrooms as more effective than the in-service provided by their school systems.

Teachers from the 2006-07 cohort not only completed the pre and post knowledge tests and responded to the Rating Scale, but each of the 25 teachers' classrooms were observed and rated by the observer. Each classroom was rated on basic science, the level of learning, definitive curriculum, and effective instruction as "on target," "near target," or "not on target." Based on the observed results, the following summaries are provided:

- Eighty-eight percent of the classrooms were rated as "on target" and 12% were rated as "near target" in terms of the basic science content of the lesson.
- Sixty-eight percent of the classrooms were rated as "on

target" and 32% were rated as "near target" in terms of the level of learning that was taking place.

- Eighty-eight percent of the classrooms were rated as "on target" and 12% were rated as "near target" in terms of the how definitive the curriculum in the classroom was.
- Seventy-two percent of the classrooms were rated as "on target" and 28% were rated as "near target" in terms of the effectiveness of the instruction.

ETSUSP teachers have reported meeting with peer teachers 60 times, with a total contact time of 32 hours. Participating teachers reported they have observed their peer teachers a total of 15 hours. Project materials shared with peer teachers ranged from microscopes to sensor probes. The most common items shared with peers represented kits, probes, hard copies of activities/lessons, periodic tables, etc. Participating teachers reported peer teachers observing their classes a total of six times. In all cases, the teachers rated the lessons as excellent. Each of the project teachers reported teaching an average of 13 lessons each month using materials or ideas gained from the summer workshop. When asked to describe the methods/strategies used to teach these lessons, they listed the following: hands-on, minds-on activities, inquiry investigations, lecture and discussion, library work, writing lab reports, and scaffolding activities techniques with students having problems learning science concepts. Nine of the project teachers reported meeting in after school science in-service sessions with their peers.

Although teachers are integral to the science education reform process, they should not be placed in a position of carrying the entire load of science education reform.

It is clear that participating teachers gained significant knowledge, applied this knowledge in their classrooms, and the lessons were perceived as effective by the teachers. Based on the classroom observations, it is also clear that the material taught in the summer workshop and provided through the follow-up visits were being implemented in the classrooms.

Student Evaluation Results

Ultimately, the success of any educational program is determined by student performance. The results presented in this article are for students whose teachers completed the Summer Institute in 2006. Student performance data were collected for the students in each of the cohorts and the results have been consistent, but results from only one year are presented here. Students in Grades 5-8 whose teachers participated in the ETSUSP Program were given the Tennessee Comprehensive Assessment Program (TCAP) Achievement Test each spring. Thus, by using the spring to spring scores for each student, we can examine performance using a pretest to posttest design. Students in Grades 9-12 must complete the Tennessee end-of-course tests (called Gateway tests) at the completion of biology regardless of what year they complete the course. However, their Science Subtest score from the TCAP in Grade 8 was available so this was used as the pretest score. Thus, a pretest/posttest design was used for students in Grades 9-12 who took biology.

Again, for students in Grades 5-8, scores on the Science portion of this test from the prior spring were used as the pretest and scores from the spring test given at the end of the experimental year were used as the posttest in establishing the pretest/posttest design. Two types of outcome scores from these tests were used to evaluate student performance—Normal Curve Equivalent (NCE) scores and their Proficiency rating (Proficient or Not Proficient). Since NCE scores are interval in nature, a repeated measures analysis of variance was used to analyze the results. The pre and post scores were the repeated measures and "Grade" was the other variable. This allowed the evaluation of significant growth at each level. Effect sizes are also reported at each grade level. It should be noted that NCE scores are derived from percentile ranks and a student who maintains his or her place in a norming distribution will stay at the *same* NCE score from pre to post. Therefore, any increase in a student's NCE score indicates an improvement of their position within his or her norming group. Thus, a significant increase of the group in terms of NCE scores would represent a positive movement from status quo. In addition, the percentage of students who move from the "Not Proficient" category to the "Proficient" category were compared using a chi square statistic. Descriptive results were provided by grade and gender. It should be noted that these data came from Tennessee's assessment program which has been recognized as a model for the country.

The scores of students in Grades 9-12 who took the Tennessee end-of-course tests (called Gateway tests) at the completion of Biology regardless of what year they completed the course were compared to their Science Subtest scores from the TCAP in Grade 8. Thus, a pretest/posttest design was also used for ETSUSP students in Grades 9-12. Again, both NCE results and the level of proficiency were collected for each student. A confidence interval was computed for the NCE results and the proportion of students in each proficiency category (Not Proficient, Proficient; Note, Advanced scores were collapsed into Proficient) was computed.

The results for Grade 5 are shown in Table 2.

The percentage of students who were proficient decreased slightly from 87.3% to 84.5%. This represents five students who moved from the "Proficient" to the "Not Proficient" categories. However, the average gain of 4.4 NCE points was statistically significant (t (180) = 4.24, p < .001) and had an effect size of .29. Since NCE scores would not be expected to change if a student just maintained his or her place in the norming group, these results demonstrate that students in the program treatment, as a group, improved their positioning among students in the overall norming group.

The results for Grades 6-8 are shown in Table 3.

The percentage of students who were proficient did not change. However, the average gain of 1.3 NCE points was statistically significant (t (1206) = 3.22, p < .001) and had an effect size of .07. Since NCE scores would not be expected to change if a student merely maintained his or her position in the norming group, these results demonstrate that students in the program treatment improved their positions on the average as compared with students in the norming group.

The Results for Grades 9-12 are shown in Table 4.

Ninety-nine and two-tenths percent of the 252 students were proficient on the posttest. This is nearing the 100% goal of No Child Left Behind. If the posttest NCE score were compared with the norming group average of 50, the posttest average is significantly above the norming group (t (176) = 4.7, p < .001). While this performance cannot be attributed only to the ETSUSP intervention, it is unlikely that this level of performance would have been observed without the ETSUSP intervention.

Table 2. Student Performance in Grade 5 Science, N = 181

	Pretest	Posttest	Change
Percent Proficient	87.3%	84.5%	-2.8%
Mean NCE Score	54.0	58.4	4.4

Table 3. Student Performance in Grade 6-7 Science, N = 1215

	Pretest	Posttest	Change
Percent Proficient	80.6%	80.6%	0.0%
Mean NCE Score	53.8	55.1	1.3

Table 4. Student Performance in Grade 9-12 Biology, N = 252

	Pretest	Posttest	Change
Percent Proficient	96.8%*	99.2%	2.4%
Mean NCE Score	NA	54.8	4.8**

*The percentage of proficient students on the Grade 8 TCAP was used as the pre measure.

**The change that is shown is the achieved NCE Score minus an NCE Score of 50, the norming group average.

Summary

Although teachers are integral to the science education reform process, they should not be placed in a position of carrying the entire load of science education reform. Science teachers will need to work within the context of policies that are "supportive of good science teaching" (NRC 1996, p. 27). The principal plays a role in the process of developing and sustaining healthy science education programs and practices by supporting professional development. In this way, the principal can create opportunities for teachers to become actively engaged in curriculum development and assessment as well as in setting standards and evaluating practices—processes that allow teachers to take more control of teaching practices. To a large extent, the desired changes in science education have not been fully realized because they have not been totally effective in influencing the classroom. Moreover, change that is championed by individual teachers and implemented in individual classrooms has a greater chance for success (Springhill, Reiman, & Thies-Springhill, 1996). Policies calling for change in practice have not always aligned with teachers' needs. Teachers have also lacked the resources to deliver an effective science education program. However, resources and funding are not enough; both teachers and administrators must play leadership roles in the creation and maintenance of an effective standards-based science education program.

While this program was for a selected group of teachers in a rural setting in Northeast Tennessee, these results demonstrate that an effective teacher professional development program with in-class follow ups with the participants can have an impact on both teacher performance and student learning. More study would need to be completed before it could be known whether this particular program could be implemented in other settings; the results suggest that the process is very promising.

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