Support Programs for New Science Teachers Can Increase Student Test Scores: Policy Implications

Donna R. Sterling and Wendy M. Frazier

George Mason University

Abstract

This six-year study examined the effect of support factors on the success of uncertified, in-service middle and high school science teachers and led to a series of policy recommendations. Using a quasi-experimental treatment-control group design, 59 uncertified teachers in 35 schools in three urban-suburban school districts were randomly assigned to a treatment or control group. The New Science Teachers' Support Network provided treatment teachers with support for two years including basic and advanced science methods courses, in-class coaching support by retired science teachers, mentoring by fellow teachers and science professors, and a website. Data were collected through online surveys, interviews, focus groups, observations, state science achievement tests (5,839 students), and science course grades (10,367 students). Policy recommendations stem from findings illustrating that (1) students enrolled in classes of teachers who received support performed significantly better on state-wide standardized science tests than students enrolled in classes of a comparable set of new science teachers who did not receive support, (2) treatment teachers' instructional skills improved over their two years in the program, (3) teachers' teaching self-efficacy fluctuated over two years, and (4) the most vital forms of support for new science teachers were supportive working conditions, supportive school culture, in-classroom support, and quality courses in how to teach science. This study has implications for teacher professional development and support provided by school districts and universities to enable new teachers to succeed at teaching and their students to succeed at learning.

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Challenge

Nationally, there is a growing shortage of science teachers (National Commission on Mathematics and Science Teaching for the 21st Century, 2000; National Research Council, 2007). As a result, many school districts are forced to hire teachers with science degrees but little or no training in education. The Report by the National Commission on Mathematics and Science Teaching for the 21st Century (NCMSTTC, 2000) reported that more than 12% of new teachers begin teaching without any formal pedagogical training and 26% of new teachers do not meet the requirements for certification in their state. These ill-prepared, new science teachers face the extra challenge of discovering how to teach on their own. Research shows that 66 percent of these new teachers will quit the profession within three years (Darling-Hammond, 2000, 2003) creating a revolving door of unqualified teachers rotating through our schools (Ingersoll, 2000; Ingersoll & Perda, 2009; Marvel, et al, 2006).

Impact of Teacher Training on Student Achievement

There are high costs associated with continually hiring, training, and losing new teachers, not only in dollars but also in staff morale and student achievement. Well-prepared teachers have the largest positive impact on high student achievement (Darling-Hammond, 2000, 2003). Teacher preparation and on-going development play a strong role in students' science performance. The Educational Testing Service found in its study, *How Teaching Matters* (Wenglinsky, 2000), that student achievement increases when teachers are skilled at teaching. For new science teachers to have the potential to produce high-achieving science students, they need to know their science content and also be skilled in how to effectively plan, teach, assess, and motivate students for learning. Based on these findings, the New Science Teachers' Support Network (NSTSN) was created to support new uncertified science teachers who possess content knowledge, but need training in proven teaching practices. Though the purpose of schools is to help students learn, in some cases the best way to help students is to help teachers.

Teacher Self-Efficacy

Research has also shown that as new teachers embark on a career in teaching, they often possess high self-efficacy, but their self-efficacy declines as they encounter the challenges of teaching, resulting in feelings of dissatisfaction and disillusionment (Moir, 1990; Rosenholtz, 1989). Teacher self-efficacy is defined as judgments of one's capability to improve student engagement and learning in the classroom (Tschannen-Moran & Woolfolk Hoy, 2001). Self-efficacy is an important construct to examine, because research indicates that teachers reporting high self-efficacy are more likely to teach their students more effectively, and foster fruitful relationships with these students (Guskey, 1988; Bandura, 1997). In contrast, teachers with low self-efficacy are more likely to detest teaching and consequently be less effective teachers and less nurturing to their students (Melby, 1995).

Previous research has shown that teachers' performance, commitment, and persistence to a task despite occasional failures has consistently correlated with teachers' self-efficacy, a measure of motivation (Guskey, 1988; Tschannen-Moran, & Woolfolk Hoy, 2001). For teachers, self-efficacy is a strong predictor of teacher retention (Darling-Hammond, 2003). Given that an individual's quality of performance and commitment to work has been linked to one's motivation level (Bandura, 1997), a goal of the NSTSN for uncertified science teachers is to increase their self-confidence as science teachers while providing them support in effective science teaching so that their increased self-confidence level is consonant with their improved teaching and student performance . Numerous studies have examined (a) the factors that impact teachers' efficacy beliefs and (b) how novice teachers' self-efficacy beliefs about effective teaching fluctuate throughout the first year of teaching (Chester & Beaudin, 1996; Tschannen-Moran & Woolfolk Hoy, 2001). However, no studies have investigated the impact of multi-district, intensive, comprehensive interventions, such as that provided by the NSTSN (e.g. mentoring and coaching integrated with coursework in how to teach), on teachers' self-efficacy. With the growing teacher shortage and, therefore, lack of fully prepared teachers that school districts are able to hire, there is a need for research that targets new uncertified science teachers, who possess bachelor's degrees in science, but need training in proven teaching practices.

Theoretical Framework

The NSTSN professional development program is grounded in the theoretical framework of a community of practice (CoP) for continuous improvement of teaching. Continuous improvement assumes that with collaborative planning, thoughtful reflection, and data collection and analysis that teachers can become more effective at helping their students learn science.

Community of Practice

Communities of practice are based on a social theory of learning where the learner is an active participant in the social community (Wenger, 1998). Engaging in a community of practice is important for fostering personal growth (van Driel, Beijaard, & Verloop, 2001; Wenger, 1998) as opposed to struggling on your own. Learners develop individual identities based on their experiences in the community. Identity development requires reflection on their practice, acknowledging how they have changed their practice, and understanding their roles in the community (Wenger, 1998). Collaborative reflection empowers teachers to "examine their beliefs and make changes in their practice" (Keys & Bryan, 2001, p. 636). In their CoP, teachers become aware of the changes in their views about teaching as they struggle with teaching and discuss their struggles with the members of their community (Akerson, Cullen, & Hanson, 2009).

A CoP draws on situated learning theory which involves a community of participants with a wide range of expertise who work collaboratively for the benefit of all (Lave, 1988; Lave & Wenger, 1990). According to Anderson and Helms (2001), "Teachers working together in collaboration towards similar goals represent the most effective path to change" (p. 9). A CoP for teaching also is supported by social cognitive theory that stresses effective professional development, addresses social needs, and develops self-motivated and self-regulated teachers (Bandura, 1997; Zimmerman, 2000). As new practices are developed, they are shared.

Communities of practice support the conceptual change process, whether it is new information or confronting misconceptions. Research suggests that in order for conceptual change to take place, deep restructuring in ways of reasoning is crucial as new associations and knowledge are connected with existing structures and knowledge (Furio, Catatayud, Barcenus, & Padilla, 2000; Hewson & Hewson, 1983; She & Liao, 2010). To create new reasoning patterns an individual responds to inadequacy using present reasoning patterns (Karplus, 2003). According to Karplus, during exploration learners gain experience with new situations, while concept introduction provides opportunity for learners to socially exchange and define new information, and concept application supports learners' abilities to apply the new concept or reasoning pattern to a new situation. Conceptual change is also based on Piaget's (1964) work of construct disequilibrium where people become dissatisfied with their current conception. This dissatisfaction is a cause for disequilibrium. Disequilibrium exists until the person strikes a balance between assimilation and accommodation. A CoP can provide a venue for discussing classroom situations and practices that do not seem to be working as efficiently as the CoP would like.

Through the long term commitment of a CoP, a variety of needs and instructional improvement can be addressed by multiple kinds of support over an extended time period. Professional development that takes place over an extended period of time is more successful at producing intended change (Supovitz & Turner, 2000, van Driel, Beijaard, & Verloop, 2001, Yoon, Duncan, Lee, Scarloss, Shapley, 2007). The extended time allows for collaboration to take place and action research to be conducted (van Driel, Beijaard, & Verloop, 2001).

Teachers are immersed in educational situations where they help students to make meaning and where they make meaning for themselves (Feldman, 2002). For those of us who are teacher educators, we need to find ways that enable teachers to change by working within the constraints of their situation and to see possibilities of what it will take to become even more effective at enabling student learning (Rhoton & Bowers, 2003). Coaching is a process where the coach and the teacher exchange ideas, implement these ideas, and reflect on their outcomes (van Driel, Beijaard, & Verloop, 2001). This takes time and on-going exploration.

Otto, Luera, and Everett (2009) found that typical teacher preparation programs failed to provide new teachers with sufficient training in how educational research can be used to improve teaching practice. Both the *National Science Education Standards* and the National Science Teachers Association (1990) call for teachers to be engaged in using and conducting research. The NSES Professional Development Standard C states that “professional development activities must provide opportunities to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science” (NRC, 1996, p. 68). Common features of

CoP and collaborative action research are ownership of specific problems that members of the CoP want to collaboratively explore, the research they conduct, the data they collect, and the actions they take (van Driel, Beijaard, &Verloop, 2001). Best practices research on effective teaching and professional development programs indicates the importance of a collective sense of commitment and responsibility for serving children (Guskey, 1995; Ruskus, Luczak, & SRI International, 1995; Sterling, 1997, 2000; Sterling, Olkin, Calinger, Howe, & Bell, 1999; U.S. Department of Education, 1999).

Continuous Improvement

Zmuda, Kuklis, and Kline (2004) define continuous improvement as “an unwavering commitment to progress” (p. 17). The education community has adopted the theories of W. Edward Deming (1986) for improving the quality of product production (student performance). Through a continuous improvement model of quality management, products and services were greatly improved through more effective product management and testing. Though his work was originally conceptualized for the business community, it applies equally to school districts, schools, and classrooms. “Every job is part of a process … At every stage there will be … continual improvement of methods and procedures” (Deming, 1986, p. 87).

Schmoker (1996) advocates that the key to continuous school improvement is “meaningful teamwork; clear, measureable goals; and the regular collection and analysis of performance data” (p. 2). The importance of teamwork for productive change is echoed by business leaders Tom Peters (1987) and W. Edward Deming (1986). According to Schmoker (1987), “teamwork is perhaps the most effective form of staff development” (p. 12). In contrast Zmuda, Kuklis, and Kline (2004) describe “for staff development to be effective, it must be an integral part of a deliberately developed continuous improvement effort” (p. 5). This is also harmonious with collaboration in a CoP (Akerson, Cullen, & Hanson, 2009; Keys & Bryan, 2001; Wenger, 1998). Schmoker's (1986) research indicates that teamwork and goals are both essential to performance, each depending on the other to build cohesion.

Through teamwork, the collaborative support provided within a CoP can assist teachers with ideas and feedback through the change process (Marzano, 2003; Marzano, Pickering, & Pollock, 2001). Additionally, Reeves (2009) notes that sustainable change depends "upon the pursuit for the greater good" (p. 125) focused on student, teacher, and overall school success. With a commitment to sustainable change to support teachers' and students' success, the NSTSN established instructional support for new, uncertified science teachers to foster their continuous improvement within a CoP based on (1) standards-based learning (American Association for the Advancement of Science, 1993; Kahle, Meece, & Scantlebury, 2000; National Research Council, 1996; VDOE, 2003), (2) teaching for understanding (Hiebert, et. al., 1997; Sterling, 2001; Wiggins & McTighe, 1998), and (3) collaborative action research as a method of investigating student conceptual understanding (Bandura, 1977; Cross, 1981; Fullan, 1991; Gallagher, 1996; NCMSTTC, 2000; Newmann & Wehlege, 1995; Rogers, 1969; Ruskus, et. al., 1995; Saurino, Bouma, & Gunnoe, 1999; Sterling, Wang, & Olkin, 1995; U.S. Department of Education, 1996, 1998; Vygotsky, 1962).

Purpose and Hypotheses

In 2002 when the current research study was planned, there was limited research about induction programs and most programs involved only assigning a mentor to a new teacher (Darling-Hammond, Chung, Andree, Richardson, & Orphanos 2009). Though this seemed to be helpful, it did not appear to be sufficient. Therefore, the current study was guided by the research question: What support for uncertified science teachers made a difference in teaching and learning and how did it make a difference? The study integrated multiple support systems and assessment measures, within a framework of continuous improvement of learning as part of creating a community of practice. Based on the research that suggests a more integrated and collaborative approach to science specific induction programs (Bianchini, Johnston, Oram, & Cavazos, 2003; Luft, 2007; Luft & Patterson, 2002; Luft, Roehrig, & Patterson, 2003; McGinnis, Parker, & Graeber, 2004; National Commission on Mathematics and Science Teaching for the 21st Century, 2000; Roehrig & Luft, 2006), the NSTSN established a culture of support for new, uncertified science teachers.

The purpose of this quasi-experimental study was to assess the impact of various support factors on the success of uncertified science teachers at the middle and high school levels. These teachers had a science degree, but little or no training or experience in teaching. As a result, they struggled in the classroom and were unprepared to meet the demands that were required of them as new teachers. The New Science Teachers' Support Network (NSTSN) was established to provide support through a CoP to these teachers during their first two years of teaching so that they would excel as teachers and remain in the profession. It was hypothesized that uncertified science teachers exposed to the various forms of support provided by the NSTSN would show higher efficacy beliefs and have higher student grades and state test scores than a control group of teachers not exposed to the supplemental support system of the NSTSN. It was also expected that treatment teachers would show significant improvement in their instructional skills and overall performance as compared to their control counterparts.

Program Description

The NSTSN was based on the work of Luft and Patterson (2002) that suggested three premises to guide induction programs. The premises are (1) long-term programs that provide support throughout the year to socialize new teachers into the process of teaching, (2) support programs that address beliefs and practices and build knowledge about science teaching, and (3) collaboration among universities, school districts, and teachers to support new teachers from a variety of perspectives with psychological, managerial, logistical, instructional, and philosophical support. These elements of support provided the underpinnings for the communities of practice that focused on continuous improvement in science teaching.

Goals of the NSTSN were to help uncertified science teachers succeed at teaching and remain in the profession. NSTSN provided an integrated support system for first and second year science teachers in secondary schools and conducted research to determine what made the most significant difference in teaching. A culture of support for new, uncertified science teachers was established through six forms of support (see Table 1). The community of practice (CoP) for the new teachers was mainly fostered through course instructors, classroom coaches, and mentors. The focus was on continuous improvement, because it was felt that new teachers with little or no teacher training would be able to learn and improve their teaching skills with the support and sharing of knowledge by experts in different facets of teaching. This led to overlapping communities of practice, all sharing the same overarching goal, to help new teachers succeed at teaching (see Figure 1). The smaller communities were a new teacher, instructor, coach, and mentors. A larger community consisted of the coaches and instructors who met and worked together to determine and share what helped new teachers. Yet another community included the new teachers and course instructors who collaborated together during science methods courses. The following six forms of support show the overlapping nature of the support from multiple perspectives in the New Science Teachers Support Network. They are listed in the intended chronological order that the teachers received the support.

Basic Science Methods Course

The first form of support available to uncertified teachers in the treatment group was a basic science methods course, EDCI 573: Teaching Science in the Secondary School, which started with a full week of planning before the school year began and then had seven follow-up sessions during the fall semester for two hours each where the teachers analyzed samples of their students work. The course was crafted with the particular needs of uncertified teachers in mind. The course built fundamental knowledge of science teaching and learning including standards-based curriculum design and research-based teaching strategies. The course focused on developing inquiry-based lessons for students to investigate science and assessing student understanding of science. During the summer the teachers learned about classroom management strategies, created an annual instructional plan that charted when they would cover each major topic in the curriculum over the academic year, taught an inquiry-based lesson they would teach the first week of school, and planned a ready-to-teach four-week unit with all support materials that clearly and directly related to the state science standards and the *National Science Education Standards* (NRC, 1996). During the fall semester, the teachers observed videotapes of themselves teaching and students' learning. Further, they conducted research on student learning. Coaches, who were retired science teachers from the participating school districts, and academic mentors, who were science content faculty from the university, participated in the methods course.

Reflective practice was a fundamental precept of the first science methods course. As the teachers began their teaching, they rejoined their classmates every two weeks to reflect on their experiences in the real world of the middle and high school classroom. The ideas proposed in the summer week of coursework were refined and revisited in the light of their own students and experiences teaching. During the fall semester, the teachers shared samples of student work from their classes (from the top, middle, and bottom third levels of student performance). They discussed what SOL concepts were targeted, what the students understood about the concept, and what the students did not understand about the concept. As a final product, teachers produced a portfolio that specifically focused on student learning.

Coaches

The second element of support for uncertified teachers in the treatment group was a cadre of coaches, who provided in-classroom (job-embedded) support for all participants in the treatment group. These coaches were retired master science teachers, recommended by science specialists in the school districts. The term "coach" was selected in order to avoid confusion between the support personnel provided by the NSTSN and the state-mandated "mentor" appointed by the schools. Coaches were assigned to the teachers within the first week that the teachers entered the program. These coaches provided hands-on support while in the classroom with the uncertified, "provisionally-licensed" teacher. They co-planned and sometimes co-taught lessons. The coaches met with the teachers for 96 hours (at least 12 visits) during the first academic year, with more visits at the beginning of the year than the end. During the second academic year, coaches continued to visit their teachers for a total of 24 hours (at least 3 visits) with one visit at the beginning, middle, and end of year. Coaches provided help and consultation for many situations the new teachers faced. Some areas in which coaches provided advice and other assistance included developing classroom and laboratory management strategies, planning short-term and long-term organization of standards-based course content, assessing student progress and achievement, and finding and creating teaching materials. Coaches met with the researchers in summer, early fall, winter, and late spring for sharing of experiences, feedback, and training each year they were in the program. For their observations and work with the teachers, coaches received a stipend to support the new teachers and complete data collection instruments.

Academic Mentors

The third form of support was an academic mentor who was a university science faculty member. The faculty members were selected because they related well to future teachers and their area of science specialty (Earth science, biology, chemistry, or physics) was the same as their assigned teacher. Academic mentors met the uncertified middle and high school science teachers in the treatment group during the summer week of classes and were available throughout the year to the new teachers for questions about the science content through email, via telephone, or face-to-face meetings. They also each presented a ”New Frontiers Seminar” during the academic year when they shared cutting edge research in their field during one of the class session for the courses.

Teaching Mentors

The fourth form of support was a teaching mentor provided for all first-year teachers, meeting a state requirement. As a result, teachers in both the treatment and control groups had a teaching mentor. Teaching mentors were full-time classroom teachers who taught in the same school as the first year teacher. They were assigned by the individual schools. Depending on their teaching schedules, mentors and novice teachers met before or after school, during planning periods if they were at the same time, or for brief “between class” conversations. The state and school divisions had no guidelines regarding the selection and training of mentors or the frequency, duration, or content of mentor/mentee interactions. Once identified by the schools, mentors assigned to teachers in the treatment group were invited to collaborate within the NSTSN. Mentors received a stipend to complete data collection instruments.

Advanced Science Methods Course

The fifth element of support for uncertified teachers in the treatment group was the second science methods course, EDCI 673: Advanced Methods of Teaching Science in Secondary Schools, which met once a week during the spring semester. Research indicates that a second science methods course is needed to provide teachers the time needed to develop in-depth knowledge of effective science instruction (Abd-El-Khalick, Bell, & Lederman, 1998; Lumpe, Haney, Czerniak, 2000; Roehrig & Luft, 2006). The second course built on the fundamentals of curriculum design and teaching from the first science methods course. The course focused on (1) using technology for students to investigate science and (2) adapting inquiry-based lessons to the special needs of students. In terms of technology, the course was designed to help uncertified science teachers build a repertoire of teaching and assessment strategies using technology to help students become scientifically literate and see relationships among science, technology, and society; demonstrate the use of technology in teaching science; and develop inquiry-based lessons for students to use technology to conduct science experiments, to research science issues, to analyze data, and to communicate findings. Utilizing the partnership of the NSTSN, exemplary inservice teachers in biology, chemistry, Earth science, and physics were selected to instruct, monitor, and support the new teachers throughout their learning. Approximately half of the class meetings were held in a public high school so that the teachers could learn in an authentic setting to improve transferability of their learning to their own classrooms. Working in content-area teams in the exemplary teacher's classroom, each team of teachers used technology that scientists use and created technology-based activities to help students learn science under the supervision and support of an exemplary teacher of the same content area. To further their knowledge and use of technology in teaching, they chose one technology they had not used before and set it up to use with their students. Technology included probeware, simulations, SMART Board technology, and course management software. In addition, the teachers created a web-based inquiry activity for their students to use to learn science, and they wrote a proposal to purchase technology for use in their classroom.

To assist uncertified teachers in their growth as educators capable of meeting the needs a diverse student population, teachers were guided and supported by experienced science teacher education faculty as they critiqued, adapted, and constructed standards-based lessons that include assessment and hands-on experiences for the diverse needs of learners with respect to gender equity; cultural diversity; the needs of English language learners; achievement levels; and the physically-, socially-, and emotionally-challenged. The teachers worked collaboratively with their peers to adapt instruction and conduct collaborative action research on student learning in order to meet the special needs of students and to extend or improve their students' understanding of science. During the process they learned about online resources that are available to assist them in their efforts toward meeting the needs of students with different needs and challenges.

Website

The sixth form of support, the NSTSN website, was created for recruiting teachers, data collection, and to support the treatment teachers in the second methods course. The NSTSN website is part of the CREST website housed on a GMU server. This website provides descriptive information about the NSTSN and recruiting information. The website also includes teacher resources that consist of links to teaching strategies to meet the special needs of students and information on technology resources for science teaching. There is also a password-protected Blackboard website to support the students in the second science methods course. Another password-protected portion of the website was utilized for data collection through online surveys.

Methodology

Participants

In this six-year study, NSTSN chronicled the experiences of 59 uncertified middle and high school science teachers in 35 schools in three large, urban-suburban school districts to determine how new teachers' needs were addressed and consequences of those actions. Each participating teacher was uncertified with a bachelor's degree in science and limited teaching experience. Teacher participants (female, N=32; male, N=27) ranged in age from 23 to 66 years, with a mean age of 34.7 years. There were 49 Caucasians, 4 African Americans, 4 Asian Americans, and 2 of mixed ethnicity. Upon entry into the program, teachers were randomly assigned to treatment (N=35) and control groups (N=24) and committed to participating for two years.

Research Design

This quasi-experimental study collected qualitative and quantitative data concurrently from teachers, students, mentors, and coaches through site visits, online surveys, and student outcome assessments. Retired science teachers conducted site visits as instructional coaches every two to three weeks throughout the teacher's first year and at the beginning, middle, and end of the second year. More than 400 site visit reports were made covering over 3,000 hours of observation. Online surveys were conducted at the beginning, middle, and end of the first and second years. Student assessment data were collected from the school districts at the end of each year on more than 10,000 students of teachers in the study.

Quantitative data were analyzed using SPSS and Microsoft Excel. Qualitative data were analyzed using NVivo to assist with the constant comparative process of grounded theory (Glaser, 1978; Glaser & Strauss, 1967; Strauss & Corbin, 1998) and cross-case synthesis (Yin, 2003). As responses were examined, they were coded, tallied, ranked, and analyzed for emergent themes (Creswell, 2008). Responses were microanalyzed with line-by-line analysis (Strauss & Corbin, 1998). They were serial coded by explicit category (Gibbs, 2002) and open coded (Glaser, 1992; Strauss & Corbin, 1998) for content. As a result, information categories, or "nodes" as termed by Gibbs (2002), were created with specific properties and dimensions that arose from the data. All analyses were reviewed by the research team in order to reach consensus regarding the name and scope of each node. After the nodes were identified and labeled, axial coding (Strauss & Corbin, 1998) was used to further define broader categories of meaning based on the properties and dimensions of ideas within the data as well as relationships and connections between nodes and categories.

The emergent themes were further analyzed using Microsoft Excel spreadsheets to analyze sequential data for patterns in change over time. This comparison between cases over time relied on both quantification of node and category results due to the number of cases included in the study as well as "argumentative interpretation" (Yin, 2003, p. 137). The result is that processes such as collection, coding, and writing were occurring at once and were continuously revisited (Glaser & Strauss, 1967).

Validity and inter-rater reliability were achieved through consensus building with three raters with experience in both teaching K-12 and science teacher preparation. In order to develop referential adequacy (Guba & Lincoln, 1989), qualitative responses from survey instruments were analyzed separately using signpost coding (Gibbs, 2002) to aid in comparison between the various qualitative data. In this process, a signpost code was used to note a specific idea or construct that was found in the data from more than one source (Gibbs, 2002). Consensual validity (Geelan, 2003) was obtained during mid and post meetings with coaches and mentors held yearly in early January and mid May. Coaches with expertise in K-12 classroom teaching were asked to reach a group consensus regarding their sense of how particular nodes and categories were defined and related to one another in the context of the teachers to which they were assigned.

Instruments

All instruments were administered at the beginning, middle, and end of the first year, as well as the middle and end of the second year of the teachers' participation unless otherwise noted.

Student Test Scores. All teachers were teaching within the same state. The state's expectations for student learning and achievement in science for grades K-12 are outlined in the state's science standards document distributed online. At the middle and high school levels, standardized tests aligned with the state's science standards are administered at end-of-course in eighth grade science, Earth science, biology, and chemistry. Raw scores for each student of each teacher participating in the study were collected at the end of each year. The passing score was 29 out of 50 for grade eight science, 30 out of 50 for Earth science, 26 out of 50 for biology, and 27 out of 50 for chemistry. Since there were no state standardized tests for seventh grade science or high school physics, no scores were available for those teachers.

Student Grades. The grades that students received in the science course which they completed with the participating teachers were collected from the three participating school districts. The grading scale was different in each district. The grading scale for students in one district ranged from A (100-94), which was equivalent to 4 points, to F (63-0), which was equivalent to 0 points. The grading scale for students in the other district ranged from A (100-93), which was equivalent to 4 points, to F (64-0), which was equivalent to 0 points (see Appendix A). Final course grades for each student of each teacher participating in the study were collected at the end of each year of the teacher's participation in the study.

Coaches' INTASC Rubric (Sterling, Kitsantas, & Matkins, 2003). This instrument was based on standards developed by the Interstate New Teacher Assessment and Support Consortium (INTASC) for beginning science teachers (INTASC, 2002) and the *Standards for Science Teacher Preparation* (NSTA, 2003), which was approved by the National Council for Accreditation of Teacher Education's Specialty Areas Studies Board. The rubric included all ten INTASC standards which measure the overall performance of teacher participants. Standards on the instrument included content, student learning, diverse learners, instruction, learning environment, communication, planning, assessment, reflective professionalism, and partnerships. Coaches were asked to rate each of their teachers for each of the standards using a four-point Likert scale (0-Unacceptable, 3-Distinguished). The instrument included an opportunity for coaches to provide a rationale for their scores. This instrument was administered during the beginning, middle, and end of both year one and year two of the teachers' participation in the study.

Coach Observation Reports. By using a naturalistic inquiry paradigm, coaches were able to focus on the process of teaching and learning. Coaches visited each of their assigned treatment teachers every two to three weeks during the teacher's first year of participation and at the beginning, middle, and end of the year during the teacher's second year of participation in the study. Visits were full-day visits where the coach was present for teaching and during the teacher's planning time. After each visit, coaches submitted electronically an overview of the class/classes, as well as described what worked, what did not work, goals for improvement and plans to meet those goals, and, finally, a description of what they did or were going to do to help or advise the teacher. In addition, they ranked the teacher on a six-point Likert scale on classroom management, planning, and provisioning. This six-point Likert rating scale is based on science standards developed by the Interstate New Teacher Assessment and Support Consortium (INTASC, 1992) and the *Standards for Science Teacher Preparation* (NSTA, 2003), which was approved by the National Council for Accreditation of Teacher Education's Specialty Areas Studies Board. The purpose of this scale is to define and measure the growth of participating teachers over time including aspects of teaching that are specific to the needs of science teachers.

Teacher Self-Efficacy Scale (Bandura, 1998). This scale measured the degree to which teachers felt they could effectively teach, as well as influence the school, parents, and students. Responses were measured on a nine-point Likert scale (1-Nothing, 9-A Great Deal). In addition, there were eight subscales including: efficacy to influence decision making, efficacy to influence school resources, instructional self-efficacy, disciplinary self-efficacy, efficacy to enlist parental involvement, efficacy to enlist community involvement, efficacy to create a positive school climate, and study-specific questions. Examples of the thirty-six items include: "How much can you do to get through to the most difficult students?" "How much can you do to get parents to become involved in school activities?" and "How much can you do to enhance the collaboration between teachers and the administration to make the school run effectively?" This instrument was administered at the beginning, middle, and end of the first year, as well as the middle and end of the second year of the teachers' participation in the study.

Teacher Efficacy Scale for Classroom Diversity (Kitsantas, DeBroux, & Concha, 2003). This scale measured the degree to which teachers felt they could effectively handle situations that involve diverse students. Twelve situations were presented to teacher participants, all of which included an example of a way in which diversity is encountered in the classroom. An example of a diverse situation in the classroom is as follows:

> You are teaching a class with students from various cultural and socioeconomic backgrounds. Some of these students show lower aspirations for academic achievement, are often lethargic, seem isolated in class, and rejected by their more economically advantaged peers. How sure are you that you will be able to create a favorable climate that will promote social interaction among your students?

Teachers' responses to these situations were measured on a ten-point Likert scale (1-Not Very Sure, 10-Very Sure). This instrument was administered at the beginning, middle, and end of the first year, as well as the middle and end of the second year of the teachers' participation in the study.

Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990). This instrument assessed teachers' efficacy beliefs to teach science and impact student learning in the science classroom. Examples of items designed to measure teachers' efficacy beliefs to teach science include: "I am typically able to answer students' science questions," "I am not very effective in monitoring science experiments," and "I wonder if I have the necessary skills to teach science." Examples of items designed to measure participating teachers' efficacy beliefs to impact student learning in the science classroom include: "When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach" and "The teacher is generally responsible for the achievement of students in science". Each item is followed with a five-point Likert scale (1-Strongly Disagree, 5-Strongly Agree). There were two subscales on this instrument – personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). This instrument was administered at the beginning, middle, and end of the first year; as well as the middle and end of the second year of the teachers' participation in the study.

Findings and Discussion

The NSTSN was a theory-based support program which provided multiple overlapping communities of practice with a focus on continuous improvement to support new provisionally licensed science teachers as they started teaching. Professional development was sustained and intensive, and focused on teaching and learning science. Research findings indicated that (1) students enrolled in classes of teachers who received support performed significantly better on state-wide standardized science tests than students enrolled in classes of a comparable set of new science teachers who did not receive support, (2) treatment teachers' instructional skills improved over their two years in the program, (3) teacher self-efficacy fluctuated over the program, (4) kinds of classroom support needed by provisionally-licensed science teachers had similarities but also differences based on their school's working conditions, and (5) the most vital forms of support for new science teachers were supportive working conditions, supportive school culture, in-classroom support, and quality courses in how to teach science.

Impact on Students

Research findings from NSTSN reveal that students enrolled in classes of teachers who received support performed significantly better on state-wide standardized science tests than students enrolled in classes of a comparable set of new science teachers who did not receive support ($M_T = 37.50$, $SD_T = 8.26$, $M_C = 35.80$, $SD_C = 8.53$, $t(5837) = 7.61$, $p = .001$). Logistic regression analysis revealed a significant difference (p = .008) between pass rates of treatment and control teachers' students. Controlling for course grade point average, socio-economic status, gender, ethnicity, disability-status, and English language learner status, treatment teachers' students were 1.225 times more likely to pass state-wide standardized science tests than control teachers' students. Additionally, more treatment teachers' students earned better course grades than students of control teachers (N_T=5,629 vs. N_C=4,193). These findings show that teachers who received professional development support in a community of practice that focus on continuous improvement were more likely to do a better job teaching and hence their students' achieved greater learning as indicated by standardized test scores. This result is substantial because the students of teachers who received support performed better on end-of-year standardized tests for the teachers' first two years. Clearly, well-prepared teachers have the largest positive impact on high student achievement (Darling-Hammond, 2000, 2003). The overall positive impact on student performance reported here is consistent with Frazier & Sterling (2008) who examined the impact of support on novice science educators and found that a synchronized combination of in-classroom support from experienced teachers, support in how to effectively teach from methods instructors, and peer support resulted in students' positive content knowledge growth. It also echoes findings from Educational Testing Service's study, *How Teaching Matters* (Wenglinsky, 2000), on the impact of teacher preparation and continuing development on student achievement. The Wenglinsky study found that student achievement increases when teachers are skilled at implementing hands-on experiences in the classroom, when students have teachers who are trained in laboratory skills, and when teachers utilized research-based assessment practices.

Impact on Teachers

Instruction. Quantitative data indicated that teachers receiving support from NSTSN experienced significant growth in their instructional skills over their first two years teaching. Specifically teachers showed significant growth in the INTASC standards areas of personal content knowledge, impact on student learning, meeting the needs of diverse learners, delivery of quality instruction, providing a positive learning environment, effectively communicating with students, planning for inquiry-based instruction, implementing research-based assessment practices, reflective professionalism, and forming partnerships within and outside the school (see Table 2). In addition, teachers showed significant growth over their first two years teaching in classroom management practices, planning for inquiry-based instruction, and provisioning of materials and supplies for instruction (see Table 3).

Self-efficacy. For teacher self-efficacy, there were no significant differences between the treatment and control groups overall on the three efficacy instruments that were utilized in this study: Teacher Self-Efficacy Scale (Bandura, 1998), Teacher Efficacy Scale for Classroom Diversity (Kitsantas, DeBroux, & Concha, 2003), or Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990). However, there were significant *time x condition* interaction effects on two subscales. For the personal science teaching efficacy (PSTE) subscale of the Science Teaching Efficacy Belief Instrument, both treatment and control teachers decreased from the beginning to the end of their first year of teaching while the treatment group's PSTE leveled off by year two and the control groups' PSTE continued to decline (F=3.36, p=.04, partial η^2=.07) (see Table 5). Similarly, for the subscale of the Teacher Self-Efficacy Scale that is designed to measure teachers' efficacy to enlist community involvement, both treatment and control teachers decreased from the beginning to the end of their first year of teaching, but the treatment teachers increased on this subscale from the end of their first year of teaching to the end of their second year of teaching while the control teachers continued to decline (F=3.66, p=.03, partial η^2=.08) (see Table 4).

Additionally, significant within group changes were observed on each of the three self-efficacy instruments. On the Teacher Self-Efficacy Scale, there were significant within group decreases on the instrument overall as well as on the instructional self-efficacy, efficacy to enlist parental involvement, efficacy to enlist community involvement, and efficacy to create a positive school climate subscales (see Table 4). For the Science Teaching Efficacy Belief Instrument, there was a significant within group decrease on the PSTE subscale (see Table 5). Finally, there was a significant within group increase on the Teacher Efficacy Scale for Classroom Diversity (see Table 6).

When instructional skills and teacher self-efficacy are viewed in conjunction with a comparison of treatment versus control teachers' student test scores, findings illustrate the delicate and complicated nature of new teachers' self-efficacy. Since treatment teachers did not know that their students were doing better, findings may be attributed to the nature of the supplemental support provided to the treatment teachers. While receiving this support, an unexpected consequence was that the treatment teachers also became aware of areas in which they could improve. This increased awareness of areas in which they could improve may have kept them from experiencing a level of self-efficacy consistent with that of a teacher who truly knows their students are learning and performing well in their classroom. Tschannen-Moran & Woolfolk Hoy (2001) found that self-efficacy was variable among new teachers and greatly impacted by struggles they face while learning to teach. This study provides further evidence of this finding and illustrates just how difficult it is to make teachers feel more confident about their teaching while helping them improve.

Challenges

In light of existing literature on the complex nature of supporting new teachers, qualitative data were collected to further illuminate and provide insight in how to best support provisionally-licensed science teachers. Qualitative findings from NSTSN identified a series of challenges teachers faced when new to teaching and how to mitigate them. By using a naturalistic inquiry paradigm, we were able to investigate the actual process of how teachers learn to effectively teach and thrive in their schools within overlapping CoPs. Emergent findings illustrated how teachers' challenges were situated within the broad categories of classroom management, planning, and instruction (see Tables 7-8). But even more informative are the categories within these three groups, because these are areas that instructors, coaches, and mentors as members of overlapping CoPs could be proactive in helping beginning teachers.

For classroom management, qualitative data indicate areas in which the teachers needed assistance (see Table 7) and their progress made (see Table 8). The first category to emerge during the teachers' first year of teaching was setting up the physical environment where teachers needed extended support in how to physically arrange their classroom in a manner to support a positive classroom environment and how to make quick adjustments to existing room arrangements when assigned to teach in multiple, non-science classrooms. Instead of assuming that teachers know how to set up the classroom and can handle teaching in multiple rooms like a veteran teacher, the coaches in the study proactively helped them set up the room at the beginning of the year to be conducive for teaching, methods instructors brainstormed strategies for how to set up the room between classes quickly, and coaches advocated in the schools for limited room changes for new teachers since they observed room changes to be detrimental to their classroom management. Establishing routines was an area where all teachers needed help.

The study's instructors, coaches, and mentors were proactive in helping the new teachers establish and conduct routine procedures, such as collecting papers or setting up experiments, and shared ways that have worked for them. Coaches were instrumental in helping new teachers brainstorming ways to adjust routines that are not working since they were there to observe the new teacher in action. Teachers struggled to effectively communicate with students, especially with regards to positive supervision of students and communication of clear instructions, which is an area that coaches were able to assist because of their direct observation with the new teachers' classes. Findings indicate that a new teacher's ability to establish a positive classroom environment relies on their ability to identify what constitutes "something worth doing" for students, since all teachers needed help with this. Discussions included how to refine lessons to engage and motivate students through connectivity of science concepts and making explicit the relevance and importance of the science being studied.

For planning, qualitative data indicate areas in which the teachers needed assistance (see Table 7) and their progress made (see Table 8). All beginning teachers needed help with short and long term planning to develop lessons for their students that effectively supported students' science knowledge and skills. Overwhelmed with how to plan daily lessons of instruction in the context of a long-range curriculum plan, the teachers also needed help in how to build and link science concepts and topics in their lessons to explicitly create connectivity for students. Teachers in the study often overlooked the necessity of being explicit with students about how the science concepts connect. Though connections may be obvious to teachers who understand the science, they may not be obvious to the learners who are trying to learn new concepts. These findings highlight the importance of inclusion of experts in a CoP who bring valuable insight to the collaborative efforts. Recently retired teachers, such as the coaches in the NSTSN, can be an asset to teacher training and support endeavors (Dunne & Newton, 2003; Heller, 2004) because they have the time and expertise with the curriculum to help new teachers. Indeed, the coaches from the program were able to assist teachers in their long and short-term planning as needed because they were a consistent presence in their classroom. However, findings indicate that teachers were essentially unable to master their assigned curricula when they taught in more than two rooms and/or taught more than two different courses.

For instruction, qualitative data indicate areas in which the teachers needed assistance (see Table 7) and their progress made (see Table 8). All new teachers need explicit help in how to extend and improve the use of teaching strategies that encourage students' active learning via the use of teacher-facilitated learning experiences. Additionally, teachers needed help with incorporating more laboratory experiences into their instruction and communicating a clear focus for students that actively engaged them in their learning at the start of the lesson. The findings from this study illustrate the condundrum that occurs when teachers who have learned in teacher-centered classrooms are now being asked to teach in the student centered classroom. It can be difficult for one to teach in a way that is not consistent with one's previous experiences as a student. For CoPs engaged in sustained, continuous improvement with a focus on effective teaching and student achievement, knowing what areas teachers need help with is the initial step to being able to effectively and efficiently support them.

Recommendations for School Leaders

Effective school leaders create school environments that nurture new teachers to succeed at teaching and reach their potential. Emergent qualitative findings from the NSTSN identified a series of challenges teachers face when new to teaching and how to mitigate them. The NSTSN research also identified the most vital forms of support for new science teachers which are supportive working conditions, supportive school culture, in-classroom support, and quality courses in how to teach science. These led to a series of policy recommendations for school leaders. During implementation of the program, analysis of qualitative findings, and formation of policy recommendations, the importance of voice and power among members in a CoP became an integral focus, especially as the new teachers interacted within their departments and schools. In light of this focus, the program's theoretical framework of a multifaceted culture of support was expanded to include critical social theory which looks at issues of equity (Bourdieu, 1979, 1984) and new feminist theory which includes socially constructed gender equality (Butler, 1990; Harding, 1986, 1991, 2006; hooks, 1981), as a perspective to emphasize the role of position and power in social interactions inherent in human culture and organizations. Consequently, the policy recommendations provided below are designed to empower new teachers as an active, valued member of their CoPs overlapping their classrooms, departments, schools, school districts, university partnership, and larger community. Table 9 summarizes the policies and practices our research suggests.

Principle 1. Establish Supportive Working Conditions

The greatest resources are committed administrators and senior teachers who establish a collegial atmosphere where all teachers support those new to the profession. This means setting up policies and procedures to provide positive working conditions and support for new teachers to succeed at teaching. It also means minimizing the seniority system where senior teachers get easy working conditions at new teachers' expense.

Teacher attrition can be reduced through attention to improving new science teachers' working conditions. Through improved working conditions, new science teachers are provided the time they need to learn how to teach well.

While it is tempting to hold off until the last possible day to hire an underprepared teacher in hopes of finding one who is more prepared, valuable training and planning time is lost. Administrators must weigh the potential benefit of hiring underprepared teachers early so that they can participate in summer professional development opportunities or prepare for teaching by reviewing school curriculum guidelines, surveying science equipment and materials, planning initial lessons, and setting up the laboratory. New teachers hired late start off teaching with a distinct disadvantage.

Careful thought needs to be given when developing teaching assignments for new science teachers. Science teachers have additional preparation time compared to teachers in other disciplines since science teachers must provision for regular classroom instruction plus laboratory-based instruction. New science teachers need to be assigned fewer different types of classes to teach so that the teacher can adequately prepare for inquiry-based, hands-on science instruction. By teaching only one type of science class (e.g. regular education chemistry), new science teachers have time during the teaching day to reflect on their teaching effectiveness. This in turn allows them to adjust their teaching during the day to increase student learning. Instead, if the teacher is getting ready to teach another type of class (e.g. a lower level chemistry course with a curriculum different from the regular course or, worse yet, a different science altogether such as biology), they do not have time to reflect and revise their plans between classes. This also increases chances for compromising students' laboratory safety.

Room assignment is important to science teachers. New science teachers need to be assigned rooms that are purposely designed for science instruction. They need to be able to teach in one room so that they are not spending their time provisioning for the same science activity in different rooms. Consider having veteran teachers take on the extra burden of changing rooms instead of new teachers.

Since new teachers need extensive time to plan for effective teaching, it is especially important that new teachers not be asked to do additional duties such as coaching sports or coordinating the science fair. Administrators and senior teachers must be cognizant of the extra time it takes new teachers to plan for regular instruction plus laboratory-based instruction, and extra duties beyond those related to science teaching should not be assigned.

Findings from six years' worth of data repeatedly highlight the importance of providing new science teachers with supportive working conditions that allow them time to thoughtfully prepared and reflect on their teaching.

Principle 2. Provide Adequate Support

Effective school leaders create school environments that nurture new teachers to succeed at teaching and reach their potential. In addition to setting up favorable working conditions for new teachers, there are three general forms of support: first week information, resource support, and teaching support. Most school divisions do a good job of providing information teachers need the first week, but this is often where support ends. Establishing a plan and identifying a person responsible for providing this information will help new teachers with tasks such as taking attendance using the school system's protocols, knowing procedures for making photocopies, and meeting resource personnel.

Another form of support is providing resources to enable teachers to teach. This goes way beyond informing teachers how to obtain textbooks, paper, and pencils. Depending on the technology available, resources range from overhead projectors, transparency pens, and transparencies to computers with projection systems. In addition to having the equipment, new teachers need someone to model effective use of equipment. Additionally, science supplies are needed to conduct science experiments. In order for students and teachers to conduct experiments, teachers need to know what science supplies and equipment should be found in all science classrooms, and the location of shared science supplies. Having easy access to supplies needed for teaching will enhance new teachers' effectiveness and likelihood of actually having students conduct laboratory experiments.

The most crucial form of support for new science teachers is providing them with coaching in order for them to perfect their teaching and enhance student learning. Retired science teachers who were highly effective at teaching are one group not to overlook as a source of support because many have skills, knowledge, and time to work with new teachers. Retirees can observe classroom teaching and provide support throughout the school day (Dunne & Newton, 2003; Heller, 2004) to ensure that science instruction is safe and effective. In addition, they can identify when a teacher is being treated poorly and serve as an advocate. Free of the constraints of teaching their own students, retired science teachers have both the time and the knowledge to make a difference. Additional possibilities are teachers on extended maternity leave or teachers who are fully released from their own teaching to help new teachers. From this group, retirees are often the most abundant, cost-effective, and knowledgeable resources with time to focus on mentoring new teachers.

The experiences of new science teachers chronicled over a span of six years highlights again and again the importance of establishing a three-stage mechanism of support (first week information, resource support, and teaching support) that nurtures new teachers to succeed at teaching and reach their potential – otherwise, many new teachers give up.

Principle 3. In-Class Support is Key to Success

From our work with teachers in the New Science Teachers' Support Network (NSTSN), there is not a generic model for supporting new science teachers. However, data from the NSTSN reveals that in-class support has a major positive impact on teaching efficacy and performance as well as student achievement.

In-class support for new science teachers makes a difference in teaching and student learning. For new science teachers to become effective quickly, they need in-class guidance while they are learning to teach and help in planning. This is especially important as many new teachers are entering teaching without education coursework or student teaching. Retired science teachers can serve as a resource for training new teachers in this manner.

Free of the constraints of teaching their own students, retirees are able to help new science teachers plan effective lessons before, during, and after school as the new teacher's schedule permits. At the beginning of the year, retirees help teachers establish effective classroom management routines. Experienced with the curriculum, retirees help new teachers with both long range and short range planning. In terms of long range planning, retirees help new teachers develop their understanding of the conceptual flow and pacing of curriculum. In terms of daily planning, retirees have experienced the ways in which student misconceptions occur and can help new science teachers address and prevent students' misconceptions.

Retirees can help new teachers identify strategies for teaching and organizational ideas for laboratory activities. Sometimes retirees help new teachers find needed science equipment that already exists in their school. Other times, retirees may perform an experiment with new teachers before they use it with students to ensure that the teachers are familiar with laboratory protocol. In terms of students' safety and access to quality instruction, new teachers must physically perform laboratory procedures themselves before using the equipment with students. Busy new teachers may skip this step, but a retiree can ensure that this occurs.

Planning can also include the development of opportunities for the retiree to model particular techniques during a lesson. If new teachers are hesitant to give up their role temporarily in the classroom for a retiree to model effective teaching, new teachers usually feel more comfortable if they have shared in the development of the parameters for when and how the retiree will teach. For example, retirees can model how to effectively ask questions or raise students' level of awareness of safety by teaching a short segment of class. Since science teachers utilize tools and hands-on materials, they need to be especially vigilant and effective managers of the classroom.

The importance of in-class support was continually evident in our study of new science teachers. Retirees were an invaluable resource in the lives of their new science teachers and the bonds forged resulted in better teaching and better student performance. Preparing to teach science involves the unique challenge of preparing for instruction that involves teaching concepts with science equipment and supplies. New science teachers need in-class support from knowledgeable professionals such as retired science teachers – otherwise, their students suffer academically.

Principle 4. Provide quality training in how to teach science

Training in how to teach science goes beyond just immediate support in the classroom to help the new teacher survive. Providing a well organized intensive courses to help new teachers see the "big picture" of teaching, assessment, and research on effective instruction is needed to help teachers look at teaching from a professional perspective. New teachers need help to plan lessons, identify effective teaching strategies, organize laboratory activities, monitor ssfety, identify common misconceptions of students, assess learning, and adapt lessons to the special needs of learners including English language learners. By taking courses in science teaching, new science teachers were able to perfect their teaching skills and enhance student learning.

Teachers have a daunting task. They must be instructional leaders, curriculum and assessment experts, special needs advisors, cheerleaders, educational visionaries, and change agents. Growing expectations for teachers to successfully teach a broad range of students with different needs and steadily improving achievement mean that classrooms and teaching typically must be redesigned rather than merely continuing as in the past. Science teachers are especially challenged in that they must incorporate science equipment and materials into their instruction and monitor safety which provides an additional dimension to their teaching demands.

In addition to teachers needing training, those whose task is to provide in-class support to new science teachers also need training and time to share what works and what doesn't for new classroom teachers. Working with adults requires a different set of skills than working with children (Bandura, 1997; Cross, 1981;& Rogers, 1969). Retirees who are recently retired exemplary classroom science teachers have the knowledge and time to provide support for new teachers. They also can take pride in giving back to the profession what they have learned during their teaching career.

The research data indicated that sustained and intensive quality training for new teachers is needed in how to teach science and assess learning for all students (Darling-Hammond, Chung, Andree, Richardson, & Orphanos, 2009). With instructional coaching, new science teachers thrive and flourish in the classroom as they explore and reflect through social interactions and support in a community of practice (Keys & Bryan, 2001; van Driel, Beijaard, & Verloop, 2001; Wenger, 1998).

Through our work with new science teachers in the NSTSN emerged a set of recommendations for establishing supportive working conditions, supportive school culture, in-classroom support, and quality courses in how to teach science that makes new science teachers more aware of what they must do to be effective teachers, supports an increase in their instructional competency, and results in statistically significant better student achievement as compared to new science teachers without the support. Teaching is a daunting task for new teachers, especially those not prepared for teaching. Dedicated school leaders can be champions for new science teachers and set up working conditions and supportive infrastructures to help new teachers succeed at teaching and remain in the profession.

Implications

This study has implications for teacher induction programs as the shortage of science teachers increases and school systems hire uncertified teachers who have degrees in science, but little or no educational training or experience teaching. These new teachers are usually placed in the classroom in a sink-or-swim situation where they are expected to learn through trial and error what works in teaching children. This is not an efficient method of providing quality teaching for children or training for teachers and results in 66% of these inexperienced teachers leaving the profession within the first three years they are in the classroom (Darling-Hammond, 2003). This study identified challenges of new, uncertified science teachers and forms of support that matter most, so that school personnel and university educators will be better able to assist under-prepared teachers to succeed at teaching and remain in the profession.

What distinguishes this particular study is the impact of the support on increased student scores on state standardized tests and increased teacher instructional skills. These results can be attributed to the integrated, long-term, intensive network of support that focused on student learning. Both the “just-in-time” help provided by in-class coaches and the “big picture” help provided by university faculty through quality course work is needed for teachers to survive and thrive. These supports are enhanced by a CoP that values continuous improvement. Since it is the mission of schools to help students learn, it behooves administrative leaders and policy makers to implement the forms of assistance within a context that helps teachers to help students learn.

This study extends beyond test scores and course grades to assess impact of program components on teachers’ self-efficacy beliefs as a measure of their potential for remaining in the profession while providing concrete, hard evidence from direct observations in classrooms to determine teachers’ instructional skills and how these change over a two-year period. While it was hypothesized that teachers in the treatment group would show higher self-efficacy beliefs to teach science and students from diverse backgrounds, findings reveal the fragile nature of efficacy among this population and illustrate the need for continued planning within university-school partnerships to address this issue.

From this research emerges a set of suggested policies and practices for school leaders to establish supportive working conditions, supportive school culture, in-classroom support, and quality courses in how to teach science that make new science teachers more aware of what they must do to be effective teachers, support an increase in their instructional competency, and result in statistically significant better student achievement as compared to new science teachers without support. In these days of tight funding, school leaders need to make difficult choices on how to support new uncertified science teachers as they struggle to learn to teach. Some of the recommendations from this study require no funding, but effective planning for how to adequately support the next generation of teachers. Other recommendations require funding. For example, a mentor teacher who has their own classes and no time to visit the beginning teacher while teaching is taking place has limited ability to help beginning teachers and may be support in name only. By contrast, a coach (retired teacher or teacher released from teaching) who visits the beginning teacher's class when teaching is taking place is able to assist with what is actually occurring in the classroom. With effective support for beginning science teachers, the students of the uncertified teachers increase their achievement in science. School leaders will have to decide what price they are willing to pay for increased student achievement and teacher performance.

Teaching is a daunting task for new teachers, especially those not prepared for teaching. Dedicated school leaders can be champions for new science teachers and set up working conditions and supportive infrastructures to help new teachers succeed and continue teaching. We concur with our colleagues (Bianchini, Johnston, Oram, & Cavazos, 2003; Luft, 2007; Luft & Patterson, 2002; Luft, Roehrig, & Patterson, 2003; McGinnis, Parker, & Graeber, 2004; Roehrig & Luft, 2006) in calling for teacher educators, school administrators, and teachers to work together to establish the policies and structures to support new science teachers as they face the challenges of learning to teach.

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References

Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education 82*, 417-436.

Akerson, V. L., Cullen, T. A., & Hanson, D. L. (2009). Fostering a community of practice through a professional development program to improve elementary teachers views of nature of science and teaching practice. *Journal of Research in Science Teaching, 46*(10), 731-744.

American Association for the Advancement of Science (AAAS). (1993). Benchmarks for science literacy. New York: Oxford University Press.

Anderson, R. D. & Helms, J. V. (2001). The ideal of standards and the reality of schools: Needed research. *Journal of Research in Science Teaching,* 38(1), 3-16.

Bandura, A. (1977). Social learning theory. Inglewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: W. H. Freeman and Co.

Bandura, A. (1998). Teacher self-efficacy scale. Retrieved from http://www.coe.ohio-state.edu/ahoy/researchinstruments.htm#Ban

Bianchini, J. A., Johnston, C. C., Oram, S. Y., & Cavazos, L. M. (2003). Learning to teach science in contemporary and eqitable ways: The successes and struggles of first-year science techers. *Science Education*, 87(3), 419-443.

Chester, M. D. & Beaudin, B. Q. (1996). Efficacy beliefs of newly hired teachers in urban schools. *American Educational Research Journal, 33*, 233-257.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: Pearson.

Cross, K. P. (1981). Adults as learners. San Francisco, CA: Jossey-Bass.

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. *Educational Policy Analysis Archives, 8*(1). Retrieved from http://epaa.asu.edu/epaa/v8n1

Darling-Hammond, L. (2003). Keeping good teachers: Why it matters, what leaders can do. *Educational Leadership, 60*(8), 6-13.

Darling-Hammond, L., Chung, W.R., Andree, A., Richardson, N., & Orphanos S. (2009). Professional Learning in the Learning Profession: A status report on teach development in the United States and abroad. School Redesign Network at Stanford University. Retrieved from: http://www.nsdc.org/news/NSDCstudy2009.pdf

Deming, W. E. (1986). *Out of crisis*. Cambridge: MIT Press.

Dunne, K. A., & Newton, A. (2003). Mentoring and coaching for teachers of science: Enhancing professional culture. In J. Rhoton & P. Bowers (Eds.), *Science Teacher Retention: Mentoring and Renewal* (pp. 71-84). Arlington, VA: National Science Teachers Association Press.

Feldman, A. (2002). Multiple perspectives for the study of teaching: Knowledge, reason, understanding, and being. *Journal of Research in Science Teaching, 39*(10), 1032-1055.

Frazier, W. M., & Sterling, D. R. (2008). Problem-based learning for science understanding. *Academic Exchange Quarterly, 12*(2), 111-115.

Fullan, M. G. (1991). The new meaning of educational change. New York: Teachers College Press.

Furio, C., Catatayud, M. L., Barcenus, S. L., & Padilla, O. M. (2000). Functional fixedness and functional reduction as common sense reasonings in chemical equilibrium and in geometry and polarity of molecules. *Science Education, 84*(5), 545-565.

Gallagher, J. J. (1996). Implementing teacher change at the school level. In D.F. Treagust, R. Duit and B.J. Fraser (Eds.), Improving teaching and learning in science and mathematics, (pp. 222-231). New York: Teachers College Press.

Glaser, B. G. (1978). *Theoretical sensitivity: Advances in the methodology of grounded theory*. Mill Valley, CA: Sociology Press.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory; strategies for qualitative research*. Chicago: Aldine Publishing Company.

Guskey, T. R. (1995). Professional development in education: In search of the optimal mix. In T. R. Guskey & M. Huberman (Eds.), Professional development in education: New paradigms and practices (pp. 114-131). New York: Teachers College Press.

Heller, D. A. (2004). *Teachers wanted: Attracting and retaining good teachers*. Alexandria, VA: Association for Supervision and Curriculum Development.

Hewson, M. G. & Hewson, P. W. (1983). Effect of instruction using students' prior knowledge and conceptual change strategies on science learning. *Journal of Research in Science Teaching, 20*(8), 731-744.

Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K. C. Wearne, D., Murray, H., Olivier, A., & Human, P. (1997). Making sense. Portsmouth, NH: Heinemann.

Ingersoll, R. (2000). *Turnover Among Mathematics and Science Teachers in the U.S.* Retrieved from http://www.ed.gov/inits/Math/glenn/Ingersollp.doc

Ingersoll, R. M., & Perda, D. (2009). *The mathematics and science teacher shortage: Facts and myth.* Retrieved from http://www.cpre.org/images/stories/cpre_pdfs/math%20science%20shortage%20paper%20march%202009%20final.pdf

Kahle, J. B., Meece, J., & Scantlebury, K. (2000). Urban African American middle school science students: Does standards-based teaching make a difference? *Journal of Research in Science Teaching,* 37(9), 1019-1041.

Karplus, R. (1777). Science teaching and the development of reasoning. *Journal of Research in Science Teaching, 140*(2), 169-175.

Keys, C. W. & Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching,* 38(6), 631-645.

Kitsantas, A., DeBroux, D., & Concha, N. (2003, August). Teacher efficacy scale for classroom diversity (TESCD): Evaluation study. Poster presented at the Annual Convention of the American Psychological Association, Toronto, Canada.

Lave, J. (1988). Cognition in practice: Mind, mathematics, and culture in everyday life. Cambridge, UK: Cambridge University Press.

Lave, J., & Wenger, E. (1990). Situated learning: Legitimate peripheral participation. Cambridge, UK: Cambridge University Press.

Luft, J. A. (2007). Minding the gap: Needed research on beginning/newly qualified science teachers. *Journal of Research in Science Teaching, 44*, 532-537.

Luft, J. A., & Patterson, N. C. (2002). Bridging the gap: Supporting beginning science teachers. *Journal of Science Teacher Education, 13*, 267-282.

Luft, J. A., Roehrig, G. H., & Patterson, N. C. (2003). Contrasting landscapes: A comparison of the impact of different induction programs on beginning secondary science teachers' practices, beliefs, and experiences. *Journal of Research in Science Teaching, 40*, 77-97.

Lumpe, Haney, Czerniak, (2000). Assessing teachers' beliefs about their science teaching context. *Journal of Research in Science Teaching, 37*(3), 275-292.

Marvel, J., Lyter, D.M., Peltola, P., Strizek, G.A., & Morton, B.A. (2007). *Teacher Attrition and Mobility: Results from the 2004–05 Teacher Follow-up Survey* (NCES 2007–307). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office. Retrieved from http://nces.ed.gov/pubs2007/2007307.pdf

Marzano, R. J. (2003). *What works in schools: Translating research into action*. Alexandria, VA: Association for Supervision and Curriculum Development.

Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom instruction that works: Research-based strategies, for increasing student achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.

McGinnis, J. R., Parker, C., & Graeber, A. O. (2004). A cultural perspective of the induction of five reform-minded beginning mathematics and science teachers. *Journal of Research in Science Teaching, 41*(7), 720-747.

Melby, L.C. (1995). *Teacher efficacy and classroom management: A study of teacher cognition, emotion, and strategy usage associated with externalizing student behavior.* Ph.D. dissertation, University of California at Los Angeles.

Moir, E. (1990). Phases of first-year teaching. Retrieved from http://www.newteachercenter.org/article2.php

National Commission on Mathematics and Science Teaching for the 21st Century. (2000). *Before it's too late.* U.S. Department of Education. Retrieved from http://www.ed.gov/americacounts/glenn

National Research Council (NRC). (1996). National science education standards. Washington, DC: National Academy Press.

National Research Council (2007) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. National Academies Press: Washington DC. Retrieved from http://books.nap.edu/catalog.php?record_id=11463

National Science Teachers Association (1990). *The role of research in science teaching*. Retrieved from http://www.nsta.org/about/positions.aspx

Newmann, F., & Wehlage, G. (1995). Successful school restructuring. Madison WI: Center on Organization and Restructuring of Schools.

Otto, C. A., Luera, G. R., Everett, S. A. (2009). An innovative course featuring action research integrated with unifying science themes. *Journal of Science Teacher Education 20*,(6), 537-552.

Peters, T. (1987). *Thriving on Chaos*. New York: Harper & Row.

Piaget, J. (1964). Development and learning. *Journal of Research in Science Teaching*, 2(3), 176-186.

Reeves, D. B. (2009). *Leading change in your school: How to conquer myths, build commitment, and get results*. Alexandria, VA: Association for Supervision and Curriculum Development.

Rhoton, J., & Bowers, P. (Eds.) (2003). *Science teacher retention: Mentoring and renewal*. Arlington, VA: NSTA Press.

Riggs, I. & Enochs, L. (1990). Toward the development of an elementary teacher□s science teaching efficacy belief instrument. Science Education, 74, 625-637.

Roehrig, G. H., & Luft, J. A. (2006). Does one size fit all? The induction experience of beginning science teachers from different teacher-preparation programs. *Journal of Research in Science Teaching, 43*, 963-985.

Rogers, C. R. (1969). Freedom to learn. Columbus, OH: Merrill.

Rosenholtz, S. J. (1989). Workplace conditions that affect teacher quality and commitment: Implications for teacher induction programs. *The Elementary School Journal, 89*, 421-439.

Ruskus, J., Luczak, J., & SRI International. (1995). Best practice in action: A descriptive analysis of exemplary teacher enhancement institutes in science and technology. Washington, DC: SRI International.

Saurino, D. R., Bourma, A., & Gunnoe, B. (1999, April). Science classroom management techniques using graphing calculator technology: A collaborative team action research approach. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Boston, MA.

Schmoke, M. (1996). *Results: The key to continuous school improvement*. Alexandria, VA: Association for Supervision and Curriculum Development.

She, H-C., & Liao, Y-W. (2010). Bridging scientific reasoning and conceptual change through adaptive web-based learning. *Journal of Research in Science Teaching*, 47(1), 91-119.

Sterling, D. R. (1997, March). Stages of conceptual change that enable teachers to adopt a student-centered approach to hands-on, inquiry-based teaching. Paper presented at the annual conference of the National Association for Research in Science Teaching, Oak Brook, IL.

Sterling, D. R. (2000, April). Strategies enabling interdisciplinary teacher teams to develop and implement standards-based teaching plans. Paper presented at the annual conference of the National Association for Research in Science Teaching, New Orleans, LA.

Sterling, D. R. (2001, March). Strategies enabling collaborative teacher teams to assess student understanding of science. Paper presented at the annual conference of the National Association for Research in Science Teaching, St. Louis, MO.

Sterling, D. R., Olkin, A. H., Calinger, B. J., Howe, A. C. & Bell, J. A. (1999). Project Alliance: Enhancing Science and Technology Instruction in the Middle Grades through Interdisciplinary Team Planning and Teaching. Online Monograph of the American Association for the Advancement of Science. Accessed November 21, 1999 at http://ehrweb.aaas.org/ehr/projectalliance/

Sterling, D. R., Wang, S., & Olkin, A. H. (1995, April). Action research: Adapting a program to an unexpected audience. Paper presented at the annual meeting of the American Education Research Association, San Francisco, CA.

Strauss, A. L. & Corbin, J. M. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd ed.). Thousand Oaks, CA: Sage Publications.

Supovitz, J.A., & Turner, H.M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching*, 37(9), 963-980.

Tschannen-Moran, M. & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*, 783-805.

U.S. Department of Education (USDOE). (1996). Pursuing excellence: A study of U.S. eighth-grade mathematics and science teaching, learning, curriculum, and achievement in international context. (NCES 97-998). Washington, DC: U.S. Government Printing Office.

U.S. Department of Education (USDOE). (1998). Pursuing excellence: A study of U.S. twelfth-grade mathematics and science achievement in international context. (NCES 98-049). Washington, DC: U.S. Government Printing Office.

U.S. Department of Education, Office of the Under Secretary. (1999). Designing effective professional development: Lessons from the Eisenhower programs. (Doc 99-3). Washington, DC.

van Driel, J.H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching,* 38(2), 137-158.

Vygotsky, L. S. (1962). Thought and language. Cambridge, MA: MIT Press.

Wenger, E. (1998). Communities of practice: Learning, meaning, and identity. New York, N.Y.: Cambridge University Press.

Wenglinsky, H. (2000). How teaching matters: Bringing the classroom back into discussions of teacher quality. Princeton, NJ: Educational Testing Service. Retrieved from http://www.ets.org/research/pic/teamat.pdf

Wiggins, G., & McTighe, J. (1998). Understanding by design. Alexandria, VA: Association for Supervision and Curriculum Development.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Yoon, K. S., Duncan, T., Lee, S. W.-Y., Scarloss, B., & Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects student achievement* (Issues &

Answers Report, REL 2007–No. 033). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest. Retrieved from http://ies.ed.gov/ncee/edlabs/regions/southwest/pdf/REL_2007033_sum.pdf

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. Pintrich, & M. Seidner (Eds.), Self-Regulation: Theory, research and application (pp. 13-39). Orlando, FL: Academic Press.

Zmuda, A. Kuklis, R. & Kline, E. (2004). *Transforming schools: Creating a culture of continuous improvement.* Alexandria, VA: Association for Supervision and Curriculum Development.

Table 1

Description of support for new teachers

Support	Who received	Year	Description	Overlap/scope
Basic Science Methods Course	Treatment	1	3 graduate credit course Built fundamental knowledge of standards-based curriculum design and research-based teaching strategies Developed inquiry-based lessons Developed classroom assessment tools Observed videotapes of themselves teaching and students' learning Analyzed samples of their students' work	Initial form of support if teacher hired before the school year starts Full week before school began with 7 follow-up fall sessions
Coach	Treatment	1 and 2	Recently retired science teachers Provided support in the classroom while	Participated in basics methods course Assigned within a week of teacher

			teaching was taking place Assisted with short and long term planning Supported teachers in any way that would help	joining program
Academic Mentor	Treatment	1 and 2	University science faculty Available throughout the year for questions about science content Presented New Frontiers Seminars in courses	Participated in basics and advanced methods courses
Teaching Mentor	Treatment and control	1	Classroom teacher in the same school as new teacher Provide information on the school's protocols Providing teaching ideas Find resources for teaching	Required by state Assigned by school
Advanced Science Methods Course	Treatment	2	3 graduate credit course Learned to use technology for	Builds on basic methods course

			students to investigate science Adapted inquiry-based lessons to the special needs of students Conducted collaborative action research	
Website	Treatment and control	1 and 2 on-going	Website Recruit teachers for support program Support teachers in the second methods course with technology and special needs resources (Treatment only) Data collection	Combination of general access and password-protected access Used in advanced methods course

Table 2

Coach ratings of treatment teachers by Interstate New Teacher Assessment and Support Consortium (INTASC) standard

	Pre		Year 1		Year 2		*F*	Partial η^2
	Mean	SD	Mean	SD	Mean	SD		
TOTAL	1.30	.39	2.01	.44	2.36	.42	72.11**	.75
Content	1.30	.43	1.99	.42	2.32	.44	66.50**	.74
Student Learning	1.09	.47	1.76	.62	2.17	.53	46.89**	.66
Diversity	1.12	.78	1.92	.64	2.40	.71	34.78**	.59
Instructional Variety	1.25	.39	2.02	.51	2.39	.41	65.01**	.73
Learning Environment	1.08	.45	1.90	.59	2.28	.52	63.33**	.73
Communication	1.39	.43	2.19	.54	2.48	.46	45.98**	.66
Planning	1.43	.41	2.07	.42	2.49	.43	60.75**	.72
Assessment	1.05	.46	1.97	.54	2.25	.49	56.52**	.70
Reflective Professional	1.66	.49	2.36	.40	2.52	.53	33.29**	.58
Partnerships	1.56	.53	2.12	.60	2.48	.47	26.00**	.52

*$p<.05$, **$p<.01$

Table 3

Coach ratings of treatment teachers' instructional skills in three emergent areas

	Pre		Year 1		Year 2		*F*	Partial η^2
	Mean	SD	Mean	SD	Mean	SD		
Classroom management	2.36	.95	3.74	.81	4.08	1.15	37.32**	.61
Planning	2.36	1.04	3.88	.88	4.24	1.20	36.34**	.60
Provisioning	2.56	1.19	4.28	.98	4.44	1.08	48.26**	.67

*p<.05, **p<.01

Table 4

Participants' teaching self-efficacy

	Pre				Year 1				Year 2				Between		Within	
	Treatment		Control		Treatment		Control		Treatment		Control		*F*	partial η^2	*F*	partial η^2
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD				
TOTAL	6.07	.86	5.77	.78	5.70	.97	5.68	.68	5.73	1.06	5.55	.68	.55	.01	3.82*	.08
Efficacy to Influence Decision Making	5.73	1.50	5.02	1.45	5.75	1.28	5.09	1.42	5.52	1.46	5.40	1.60	2.15	.05	.07	.00
Efficacy to Influence School Resources	5.58	2.24	5.76	1.22	5.96	1.90	5.86	1.59	6.08	1.67	5.71	1.62	.05	.00	.49	.01
Instructional Self-Efficacy	5.96	.74	5.98	.93	5.52	1.27	5.68	.64	5.63	1.04	5.46	.80	.00	.00	7.24**	.14
Disciplinary Self-Efficacy	7.11	1.07	6.40	1.11	6.75	1.11	6.70	.73	6.71	1.26	6.49	.76	1.75	.04	.52	.01

Efficacy to Enlist Parental Involvement	6.28	.98	6.19	1.03	5.86	1.23	5.83	.96	5.74	1.43	5.41	1.01	.29	.01	7.62**	.15
Efficacy to Enlist Community Involvement	5.49	1.31	5.02	1.07	4.23	1.58	4.81	1.05	4.45	1.94	4.45	1.10	.01	.00	10.28**	.19
Efficacy to Create a Positive School Climate	6.33	.86	6.02	.89	5.86	1.22	5.80	.82	5.97	.12	5.91	.71	.34	.01	3.64*	.08

*p<.05, **p<.01

Table 5

Participants'science teaching efficacy

	Pre				Year 1				Year 2				Between		Within	
	Treatment		Control		Treatment		Control		Treatment		Control		*F*	partial η^2	*F*	partial η^2
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD				
Total	2.16	.41	2.25	.33	2.07	.43	2.27	.33	2.07	.41	2.24	.34	2.40	.05	.46	.01
PSTE	1.93	.53	1.91	.50	1.63	.38	1.88	.51	1.61	.3	1.76	.47	1.11	.03	9.84**	.19
STOE	2.36	.39	2.57	.31	2.49	.53	2.63	.38	2.50	.52	2.69	.37	.02	.00	2.22	.05

*p<.05, **p<.01

Table 6

Participants' diversity self-efficacy

	Pre				Year 1				Year 2				Between		Within	
	Treatment		Control		Treatment		Control		Treatment		Control		*F*	partial η^2	*F*	partial η^2
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD				
Total	6.08	1.61	6.23	1.46	6.06	1.80	6.46	1.17	6.55	1.62	6.74	1.01	.40	.01	3.76*	.08

*p<.05, **p<.01

Table 7

Classroom Support Needed by Provisionally-licensed Science Teachers (N=34)

Categories	Emergent Sub-categories	Portion of teachers needed help to …
Classroom Management	physical environment	35% (12) rearrange student desks and other classroom furniture in order to create a more conducive learning environment
		24% (8) teach in non-science classrooms that had no water or gas and minimal electrical outlets
		24% (8) teach in two or more different rooms, making it extremely difficult to establish a productive classroom setting
	establishing routines and classroom policies	100% (34) establish routines
		68% (23) have a more established procedure for grouping students for activities
		50% (17) remember to bring closure to their lessons
		44% (15) use seating charts more consistently to streamline attendance-taking procedures
		35% (12) develop a procedure for calling on students
		18% (6) establish and enforce classroom rules
	provisioning of materials	24% (8) have all materials available and organized for student use
		15% (5) locate and organize lab equipment and repair

		nonfunctional equipment
	teacher-student interactions	68% (23) effectively supervise students 44% (15) communicate clear expectations 24% (8) use positive reinforcement more often and pause until they had the class' attention 9% (3) control behavior through proximity 6% (2) avoid leaving the room upon occasion during class
	having "something worth doing" for students	100% (34) refine lessons to engage and motivate students through connectivity of science concepts and make explicit the relevance and importance of the science being studied
Planning	content	100% (34) plan and develop lessons for the students 100% (34) build and link science concepts and topics in their lessons to explicitly create connectivity 68% (23) determine the scope and sequence of content for long-range planning
	instruction	75% (25) plan detailed lesson plans to support appropriate pacing 75% (25) plan for laboratory experiences using hands-on materials 75% (25) pace learning activities
	organization	35% (12) organize teaching materials for effective

		instruction
		15% (5) plan for teaching in three or more rooms during the day
	assessment	68% (23) plan for and improve assessment including how to grade and provide feedback
Instruction	focusing lessons	56% (19) focus lessons well for students at the beginning of class including using warm-up activities more consistently
	laboratory activities	68% (23) develop additional laboratory activities to specifically match their curriculum
		44% (15) work on providing clearer directions for laboratory activities
		18% (6) conduct laboratory activities more often
	student-centered instruction	100% (34) extend and improve their use of teaching strategies that encourage students' active learning via the use of teacher-facilitated learning experiences
	differentiation	26% (9) develop reading strategies for use in their classroom
		26% (9) explicitly assist with differentiation techniques for the large number of special education
		26% (9) better address the needs of English language learners in their classes

Table 8

Progress Made by Provisionally-licensed Science Teachers (N=34)

Category	Year 1 Qualitative Findings	Year 2 Progress Across All Participants
Classroom Management	82% (28) improved in their ability to provision materials for laboratory instruction	used routines and policies to support learning
	82% (28) consistently used an agenda	still needed detailed, customized support in how to best use routines and policies to create a positive learning environment
	75% (25) routinely utilized warm up activities	
	75% (25) improved in how they grouped students for activities	progressed in their rapport with students to promote the students' interest in science
	68% (23) had excellent student rapport	
	50% (17) improved in their ability to provide closure to their lessons	mostly took full advantage of learning time allotted during class
	44% (15) routinely used humor when interacting with students	
Planning	100% (34) started to develop a repertoire of teaching strategies that assist in student learning	have a general understanding of the scope and sequence of the course and are better able to plan
	100% (34) started to develop a system to organize and store teaching materials in a convenient manner and maintain a record of their teaching	are able to handle difficult teaching assignments and multiple classrooms better
		establish an organization system for

		teaching materials and records start to improve and expand assessment practices including types of assessment create an assessment plan and start to make assessment strategies more efficient, but struggled with how to get feedback to students in a time efficient manner
Instruction	100% (34) became aware of the need to extend and improve their use of teaching strategies that encourage active students learning via the use of teacher-facilitated learning experiences 26% (9) focused on developing strategies to differentiate instruction for English language learners and special education students	gave better directions for laboratory activities thus decreasing confusion and increasing student learning became more comfortable with differentiating instruction for English language learners and special education students

Note. Year 2 summarizes themes of improvement across reports rather than tabulating them. This was necessary to avoid including data by omission because with only three reports in year 2 all topics that teachers improved in were not mentioned consistently.

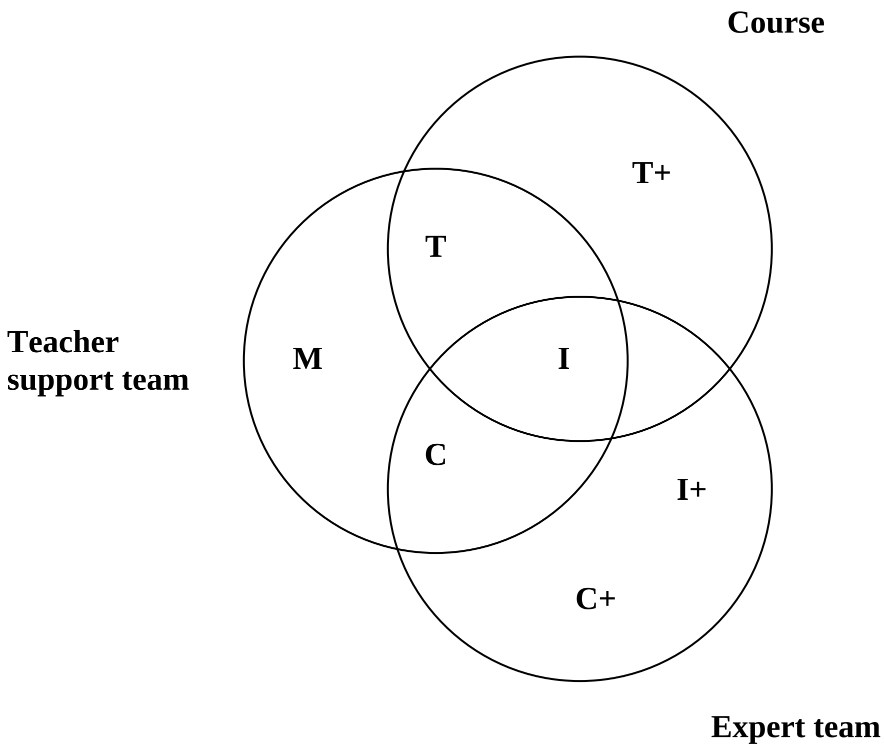
Table 9

Recommendations for School Leaders

Type of Support	Recommendation
Working Conditions	Hire early and assign classes so that the new teacher can start planning to teach before they have to start school.
	Assign new teachers only one class preparation so they have time to reflect and revise lessons between class periods to perfect their teaching skills.
	Provide new science teachers their own room in which to teach instead of having them float between classrooms with a cart.
	Protect new teachers from additional school duties beyond those directly related to teaching their own classes.

School Culture	Nurture new teachers in a supportive school environment where teachers help each other and the entire faculty is focused on helping students. Establish a plan and identify a person or team to provide new teachers with an orientation to the school, policies, and procedures. Provide teaching resources including teaching supplies, computer equipment, and science equipment, along with a person to demonstrate effective equipment use. Provide an in-class coach/mentor to support the new teachers while learning to teach, such as a retired science teacher with experience teaching the same content area as the new teacher who has time to observe the new teachers teaching over an extended period of time and suggest how to more effectively impact student learning.
In-Class Support	To encourage effective teaching and learning, coaches/mentors who spend extended time in and out of the classroom with the new teacher can: Observe new science teachers teaching and provide constructive feedback, Assist in establishing classroom routines, Problem solve classroom management challenges, Share about the school's culture, Participate in long and short-term planning with emphasis on sequence and pace, Identify students' common misconceptions and assist with planning to

	mitigate them,
	Provide lesson ideas, materials, and equipment or help locate equipment,
	Perform experiments with new science teachers prior to use with students,
	Model effective, safe instruction for large and small groups, and
	Focus on increasing student learning.
Quality training	Establish a partnership with a local college or university to provide quality courses for new teachers in how to teach and assess science.
	Provide quality training for those who provide in-class support in how to support and mentor new teachers.



T=teacher, I=instructor, C=coach, M=mentors, +=others

Figure 1. Overlapping communities of practice