Developing Science and Mathematics Teacher Leaders Through a Math, Science & Technology Initiative

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Abstract

This study explores the effects of a professional development teacher leadership training program on the pedagogical and content development of math and science teacher leaders at the elementary level. The study is qualitative in nature, and the authors collected data using the online survey instrument Survey Monkey. The major implications of the study are twofold: (a) The professional development training that the fellows received enhanced their pedagogical and content knowledge and provided them the necessary experience to be effective teacher leaders; and (b) meaningful teacher leader-teacher relationships have a positive impact on teachers embracing an inquiry-based style of teaching using a Math, Science, and Technology Initiative program.

The idea of teacher leadership has gained much traction over the last decade. This is partly due to the notion that:

> Teacher leadership aligns with notions of individual empowerment and localization of management that have extended throughout the history of the United States. Specifically, the concept of teacher leadership suggests that teachers rightly and importantly hold a central position in the ways schools operate and in the core functions of teaching and learning. (York-Barr & Duke, 2004, p. 255)

Teacher leaders, as defined by Katzenmeyer and Moller (1996), are those "who lead within and beyond the classroom, influence others toward improved educational practice, and identify with and contribute to a community of teacher leaders" (p. 6). York-Barr and Duke (2004) defined the term *teacher leader* in a similar manner in that they believed teacher leadership is "the process by which teachers, individually or collectively, influence their colleagues, principals, and other members of school communities to improve teaching and learning practices with the aim of increased student learning and achievement" (pp. 287–288). This is not to say that teachers who are not teacher leaders are not good and effective teachers but that teacher leaders have "something extra" that sets them apart from just being a good teacher. Curtis (2013) summarized it in this manner:

> Given our newly refined ability to distinguish between teachers and their effectiveness, and the imperative brought on by the Common Core standards to deliver instruction at a more sophisticated level, it is no longer reasonable or tenable to keep treating teachers the same. Instead, school systems should provide their highest-performing teachers with leadership roles that both

elevate the profession and enable them to have the greatest impact on colleagues and students. (p. iii)

The concept of teacher leadership has received attention because schools and school districts are constantly working to develop strategies to improve schools and student learning (Franklin, 2012). Schools are realizing that the principal or administrative leader cannot possibly meet the challenge of improvement alone as the demands of today are unprecedented (Curtis, 2013; Danielson, 2007). Most would agree that teachers with effective instructional strategies are essential if improvement is to occur. The goal of teacher leadership is to improve student achievement by mirroring the characteristics of effective classroom teachers (such as work ethic and persona) and transferring these critical skills to improve teachers' pedagogy. York-Barr and Duke (2004) further asserted that:

> Recognition of teacher leadership stems in part from new understandings about organizational development and leadership that suggest active involvement by individuals at all levels and within all domains of an organization is necessary if change is to take hold (Ogawa & Bossert, 1995; Spillane, Halverson & Diamond, 2001). Educational improvement at the level of instruction, for example, necessarily involves leadership by teachers in classrooms and with peers. (p. 255)

There is disagreement about the importance of certain elements when it comes to student learning. Some believe class size is a significant component (Pianta & Hamre, 2009; Ponitz, Rimm-Kaufman, Brock & Nathanson, 2009). Others believe societal factors play the most influential role (Cummins, 2012; Schofield & Bangs, 2006), while some claim that socioeconomic status is one of the most important variables (Gassama, 2012; Naiditch, 2010). Regardless of which issue is most valuable, one would be hard pressed to find anyone who disagrees with the notion that "No single principle of school reform is more valid or durable than the maxim that student learning depends first, last, and always on the quality of the teachers" (Usdan et al., 2001, p. 1). Simply put, teachers matter (Jacobs, 2012).

Rationale for Research

The primary goal of the Math, Science, and Technology Initiative (MSTI) Fellows program was to create teacher leaders at the elementary level in science and mathematics who would (a) increase participating fellows' content and pedagogical knowledge, and (b) increase the self-efficacy of participating fellows in science or mathematics. The MSTI Fellows program was designed to extensively train teachers, designated as fellows upon acceptance into the program, for one year outside of the fellows' home school to be a MSTI teacher leader. The one year of professional development included two parts: the fellows being mentored and trained by a MSTI specialist, and the fellows coaching classroom teachers in the school district. Fellows then returned to their home school after the one year was completed. The authors sought to explore the following questions in the MSTI Fellows program:

1. Did the fellows grow in their content knowledge and self-efficacy in science and mathematics?
2. How did the fellows perceive the professional development they received?
3. What challenges did the fellows face when collaborating with and coaching classroom teachers?

Ultimately, the researchers sought to determine how a sustained, one-year professional development experience contributed to the growth of elementary teachers in science and mathematics as teacher leaders. This research examined these questions in relation to the participants' perception of their experiences in the MSTI Fellows program.

What Is the MSTI Program?

MSTI is a statewide initiative whereby an inquiry-based mathematics and science support program emphasized problem solving and hands-on learning. Using the MSTI as the foundation for training, teacher leaders facilitated the implementation of effective professional development strategies. This bridged the gap between successful and innovative short-term practice and long-term institutionalization of teaching strategies. These strategies promote teacher understanding and incorporation of the principles of inquiry-based teaching of science and mathematics to positively impact student achievement (Banerjee, 2010; Kuhlthau & Maniotes, 2010). When we make reference to *inquiry*, our perspective is grounded in the National Science Education Standards (1996) description:

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (p. 23)

Inquiry-based teaching and learning is the principal upon which MSTI was founded. MSTI recognizes that there is not a single best method to the teaching and learning of science or mathematics. Inquiry is not exclusively hands-on science and mathematics or reading about science or mathematics in a textbook, nor is it merely refraining from lecturing about science. Inquiry involves teachers utilizing a multitude of classroom techniques. It is multifaceted in that it involves investigations, observations, asking questions, and examining what is already known and moving forward to develop new ideas and conclusions (National Science Education Standards, 1996). In short, "students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined" (National Research Council, 2012, p. 218). The MSTI recognizes that this process begins with the teacher.

The MSTI has been proven successful in raising the percentage of students who meet or exceeded the standards in participating schools (Newman et al., 2012). The Southeast Regional Educational Laboratory SERVE Center at the University of North Carolina at Greensboro, aided by the Empirical Education Inc. and the Academy for Education Development (AED), was hired by the United States Department of Education to perform an outside randomized controlled evaluation of the effectiveness of the MSTI. The evaluation found the MSTI was highly effective with regard to student achievement in science and mathematics (Newman et al., 2012) and reported the following:

- Findings showed statistically significant and meaningful student achievement in the MSTI schools. Students who attended MSTI schools and classes for one year showed a gain of two percentile points on the SAT-10 mathematics problem solving assessment compared to students who did not attend the MSTI schools. These gains compare to an average of 28 extra days of schooling in math (almost one and a half months).

- Exploratory results indicated students who attended MSTI schools for at least two years showed a gain of 4 percentile points compared to students who did not attend MSTI schools. These gains equate to an average of 50 extra days of schooling in math.
- While the results for science were not statistically significant in the first year, over a period of two years, students in MSTI schools showed significant gains when compared to students in non-MSTI schools, with a 5% gain in scores. Scale score increases were even 20% greater than the strong gains in math. However, because data were not available for every grade in science, conversion to "additional days" was not possible.

The findings indicate that the Professional Development (PD) received by the teachers is one of the primary reasons for the success of the MSTI. The results also show that the support the MSTI teachers experienced was a crucial component of the students' progress. Students in classes with teachers who were MSTI trained and supported out-performed students in non-MSTI teacher classrooms.

Description of the MSTI Fellows Program

The research described in this study was conducted through one of the state's largest regional centers. The MSTI project was funded at approximately $3.0M annually to provide mathematics and science inquiry-based instructional materials, intensive training for the use of these instructional resources, and continuing classroom support to ensure high-quality instruction. The design feature of the MSTI Fellows program recognizes the positive effect and essential role of teachers leading teachers (Shagrir, 2012; Stein, Smith & Silver, 1999; Wepner, Krute, & Jacobs, 2009) in science or mathematics. The goal of the MSTI Fellows program was to assist teachers in gaining a better understanding of science or mathematics that included:

- An awareness of basic ideas that were revisited and reinforced;
- A deep understanding of connections between concepts and procedures;
- Familiarity with various approaches to problem solving; and
- An awareness of how concepts relate and build upon each other (Ma, 1999).

The program provided selected fellows the opportunity to develop skills to become better teachers within their own classrooms, as well as the knowledge and skills to become a resource for other teachers.

Effective professional development increases teachers' knowledge and skills and changes classroom practice (Brand & Moore, 2010). It may also be asserted that a well-planned, comprehensive coaching program increases the instructional effectiveness of teachers. The Recursive Model of Teacher Leadership (Morehead & Sledge, 2006) uses this concept as its foundation by having teachers (a) become experts in the classroom, (b) become a resource for other teachers, and (c) work in conjunction with other stakeholders to build capacity. "The challenge is to make all schools places where teachers find the support they need to succeed with their students" (ALSDE, 2007, p. 249). As teacher leaders develop these attributes, they can play a vital role in assisting other teachers to improve their content and pedagogical knowledge, to ultimately have a positive impact on student achievement (Curtis, 2013).

There is no shortage of literature on the topic of teacher leadership, and upon its study common themes begin to emerge. York-Barr and Duke (2004) place these commonalities into four categories: a) benefits of employee participation; b) expertise about teaching and learning; c) acknowledgment, opportunities, and rewards for accomplished teachers; and d) benefits to students. The MSTI Fellows program incorporated these four categories into their teacher leader program by a) embracing participation of both teacher leaders and classroom teachers; b) recognizing existing pedagogical excellence through the selection process of fellows and building upon that excellence to develop expertise during the program; c) structuring opportunities for fellows to attend local and national professional meetings, providing a stipend for their efforts, and regular opportunities to meet with university content, pedagogical, and leadership faculty; and (d) examining teacher reports and student data in classrooms and schools where fellows were engaged.

Methods

The intent of the MSTI Fellows program was to strengthen fellows' knowledge of the math and science content, pedagogical knowledge, and leadership skills by providing them with experiences that would allow them to reach a mastery level. The project engaged two cohorts of teachers in one year of professional development activities to assist in achieving these goals over the course of two years. The criteria for selecting the participants included: (a) a recommendation by the teacher's principal, (b) a minimum of three years of experience with the MSTI science and math, (c) evidence of effective interpersonal and collaborative skills, and (d) an agreement to return to their home school for at least one year to serve as a MSTI teacher leader.

Once participants were selected, their contracts were acquired using grant funds for one academic year so they could receive the professional development necessary to become MSTI specialists. In this role, the teachers—now designated as fellows—were assigned to work in the regional MSTI Center under the supervision of the MSTI Director and were responsible for providing science or math coaching and support for teachers in MSTI certified schools in the service region.

Participants

Seven elementary classroom teachers participated in the professional development portion of the MSTI Fellows program. Participants were in two cohorts, with each participant having one-year experience in the MSTI Fellows program. The first cohort (year one) consisted of four teachers, and the second cohort (year two) consisted of three teachers. All participants were female teachers with experience ranging from four to twenty-four years of teaching. As fellows, five teachers were focused in mathematics and two teachers were focused in science, but all were teachers of both science and math by virtue of being elementary teachers. In addition, they all were employed in Title I schools. Their participation in the project consisted of coaching teachers in urban, rural, and suburban schools.

Leadership, Pedagogy, and Content

Under the tutelage of veteran MSTI specialists, the experience gave fellows an opportunity to learn how the entire district's and state's math and science curriculum was organized through grade levels. This understanding widened their knowledge and perspective of the curriculum and was a crucial component to the process of training the fellows to be effective teacher leaders. The fellows developed further comprehension of MSTI's application and gained both a horizontal and vertical perspective of

how MSTI support could be used. Having knowledge of the district's math and science curriculum across grade levels provided fellows the opportunity to expand their insight into the inter-connectedness of K–5 education so they could better support the teachers whom they would be assisting.

The fellows received on-the-job training to function as MSTI specialists in the process of learning how to become a teacher leader. The existing practice of MSTI provides on-site support for elementary teachers in science and math through the use of MSTI specialists who support schools that use the program throughout the academic year. The detailed and intensive training as a MSTI specialist allowed fellows to acquire the skills needed to become effective teacher leaders.

At the beginning of the experience, each fellow shadowed a seasoned MSTI specialist to support their growth and development in various schools for approximately nine weeks. During this nine-week period, fellows worked with individual MSTI specialists, groups of specialists as a part of a team (depending on their subject area), and with one another to begin to master their new role. The experienced specialists responded to questions, clarified processes, and mentored the fellows in the role of becoming teacher leaders. This new role demanded that the Fellows master both the effective components of teacher leadership and content in order to be successful. During the initial nine-week period, the fellows experienced a gradual release of responsibility (Pearson & Gallagher, 1983) so at the conclusion of this time frame, they could operate independently in the schools with teachers who needed assistance.

Learning continued throughout the school year as fellows planned lessons for modeling and collaborated with administrators and teachers who wanted coaching. They continued to work in the same schools and engage in weekly team meetings led by the Regional MSTI Director. One of the greatest benefits of the experience was that fellows were able to immediately put what they learned into practice as they coached classroom teachers.

Fellows as Learners

One of the most important roles that the fellows had to master was that of a learner. Learners model continual improvement and pursue lifelong discovery. They then use these skills to help all teachers assist students to achieve their goals. Not only did fellows gain familiarity with the science or math content of MSTI, but they gained valuable coaching and leadership skills as well. The process of learning to be a coach was equally as important as the content knowledge, for it is this knowledge that assisted the fellows in effectively leading teachers.

Support was available to the fellows in the form of an experienced MSTI specialist who served as a mentor. Fellows met each week with their mentor, other MSTI specialists, other fellows, and the MSTI project director to discuss the accomplishments and challenges of the previous week

Data Collection and Analysis

Data were collected over a two-year period to determine if the MSTI professional development for fellows contributed to their growth in science and mathematics as teacher leaders. Survey data focused on the experiences of the fellows who participated in the MSTI Fellows program, relating to the expansion of pedagogical and content knowledge connected to teacher leadership. Quantitative data for this research were collected using the online survey instrument SurveyMonkey (http://www.surveymonkey.com), and through unstructured, individual interviews.

Data were collected from a survey that was administered to each participant from both cohorts at the conclusion of each one-year fellowship. The survey contained both open-ended questions regarding the training the fellows received and their activities in the schools. The survey was designed to assess each phase of the participants' experiences over the course of their fellowship year by soliciting responses about assisting other teachers, content and pedagogical knowledge, and coaching. In addition, the survey assessed participants' satisfaction with the program's perceived impact on bridging the gap between theory and practice. This bridge involves building a community of learners, classroom instruction, and personal professional development. At the completion of year one and year two, participants were interviewed individually to determine their perceptions of the program, including the professional development they received, and their professional growth in both content and as teacher leaders.

Open-ended questions are used when the researcher is interested in the participants' perceptions or points of view (Patton, 1990) so that the participants are free to express their perspectives according to what they thought important. The participants were encouraged to be truthful in their responses so that a better experience could be created for future teachers who would participate in the program. The individual interviews were unstructured (Nichols, 1991), providing the interviewer opportunity to probe more deeply into the initial responses to gain more detail.

Aspects of the constant comparative method of qualitative analysis (Glasser, 1965) served as a guide for this research. Quotes, themes, and assertions were mutually discussed among the researchers in an effort to arrive at consensus and safeguard against the misrepresentation or misinterpretation of the data. This analysis allowed researchers to compare, delimit, and integrate the categories based on characteristics in order to generate integrated theoretical ideas. Assertions were developed from these themes to represent the participants' perceptions of their experience.

Findings

The responses that represent the teachers' thoughts, experiences, and feelings of participating in the one-year MSTI Fellows program were categorized into two overarching themes. These themes were: (a) the professional development training that the fellows received enhanced both their pedagogical and content knowledge while providing them with the experience needed to be effective teacher leaders, and (b) meaningful fellow-classroom teacher relationships have a positive impact on teachers embracing an MSTI inquiry-based style of instruction. The fellows conversed passionately about their development as teacher leaders during the MSTI Fellows program. Each theme will be discussed with supporting assertions and statements from the fellows.

Professional Development Training

The fellows' discussion centered on their experiences in the one-year fellowship and how that experience aided their growth as teacher leaders. Each participant suggested that the fellowship and its activities strengthened their teaching attributes, which in turn strengthened their abilities to be effective teacher leaders. Typical professional development programs for classroom teachers are generally not as in-depth as the MSTI program which allowed participants to gain skills on a deeper level.

Fellows received a hands-on type of professional development where they learned theory and techniques and immediately applied them in their role of assisting classroom teachers. The classrooms

served as laboratories where they could experiment with what they were learning while developing their leadership identity. Four assertions surfaced from the participants about what they gained as a result of engaging in the process of learning to be teacher leaders. These assertions are presented and supported with responses from participants' open-ended survey items and interviews.

Assertion 1. The fellows became more reflective regarding their personal learning as they discovered gaps in their own knowledge as a result of participating in professional development activities geared towards increasing their understanding of inquiry-based teaching and learning.

Although the fellows were highly recommended by their principals to participate based on their skill level, they soon realized that they had gaps in their knowledge with respect to content and inquiry-based teaching. Many fellows indicated that the Five E learning cycle (Engage, Explore, Explain, Extend, Evaluate) significantly assisted them in gaining a better understanding of inquiry-based teaching. Some sample quotes include:

In the past I had never consciously used the 5E model to teach. After learning the 5Es this year I realized that I had been implementing it, but not to its' full potential. After this year I am more in tuned with how to question more effectively by using meaningful, probing questions. I have thoroughly enjoyed seeing the benefits of the 5Es this year. I am excited to use the 5E model with my future students. I feel that I have a greater understanding of a 5E lesson and its components. I think I will be able to question my students in such a way that they will be able to retain and recall their new knowledge.

As a fellow this year I have a greater understanding of inquiry learning and the components and characteristics that compose this learning. In my classroom I struggled at times with balancing the MSTI investigations, the pacing guide, and other county requirements. This year I was able to coach teachers using the new investigations and I saw a renewed excitement in teachers. They felt as if they could implement the MSTI program into their daily plans. It is also inspiring to see students learn so much and have a deeper understanding of concepts through inquiry learning and for teachers to see the results as well.

I have always been an inquiry-based teacher but I have learned so much content, strategies and questioning skills this year than I never knew before. I have just learned so much about math content and math instruction and feel that I am strengthened as an educator.

I think my beliefs have remained the same. However, the amount of information I have acquired will be helpful to me. I grew more as a teacher in one year than I had in several years of self-paced learning. The way I teach will be forever changed.

The biggest "aha!" for me was the deliberate use of the 5E model of inquiry learning. I knew the 5Es, but putting it to practice as a step-by-step way of thinking and planning has been very powerful.

These comments shed light on the fellows becoming more reflective practitioners as they committed to taking their learning to new levels. Each of the participants revealed that though they felt they started the program with a deep knowledge of content, dedicating time to the professional development made a tremendous difference on their overall knowledge base.

Assertion 2. As a result of participating in the MSTI Fellows program, the fellows were able to personalize the meaning of inquiry-based teaching and learning as their understanding increased.

The teachers discussed their perspective about inquiry-based teaching and learning and how they gleaned a solid understanding of it and what it looked like in practice. Their discussion of inquiry indicated that their level of understanding of inquiry-based teaching deepened while participating in the program. Some sample quotes include:

To me, inquiry means making children curious to know more and giving them the skills and opportunity to seek their own answers. Inquiry learning is about providing students an environment where they can, without fear, ask questions, try to find the answers to these questions through exploration and experimentation, and rely on their peers for feedback and additional knowledge. Inquiry is about a teacher asking the right questions to guide this learning, but allowing children the opportunity to construct meaning at their own pace and in their own way. Inquiry is about being flexible as a teacher and as a student and being confident in your ability to figure things out on your own.

Inquiry base instruction focuses on using and learning content, to develop new learning and solve problems. It is student centered, with the teacher as a facilitator of learning eliciting questions to derive at the chosen objective. It allows the student to explore how they derived at their thinking instead of measuring the unknown and trying to implant new without a connection. Students are engaged and actively involved through the experience, learning at that point is not laborious but fascinating to the student.

Inquiry-based teaching is facilitating student learning by allowing students to be actively involved in their own learning. Students are the explorers and the explainers and ultimately the decision makers and problem solvers. Through well thought out and well placed questions, teachers become facilitators of student learning allowing for more student ownership in the learning process.

Inquiry-based teaching is an approach to learning where students are provided meaningful opportunities to explore concepts and formulate understanding through the guidance of the teacher's use of questioning. Encouraging kids to question and explain their thinking is a critical part to inquiry learning. Students take ownership of their learning that leads to students using critical thinking skills, being able to problem solve, and apply their new knowledge to different situations.

The strategic instruction of MSTI is the inquiry-based approach for both teachers and students. Through this instruction, fellows deepened their understanding that inquiry teaching is essential for helping students develop critical thinking skills that are transferable to novel settings.

Assertion 3. The totality of the fellows' experiences strengthened their confidence with regard to both their pedagogical and content knowledge. The professional development allowed fellows to grow greatly in their content and pedagogical knowledge. Gaining this knowledge increased their self-efficacy with regard to assisting teachers with inquiry-based teaching. They learned research based practices and immediately transferred that knowledge to the teachers they were assisting. As the fellows' comprehension increased they became more confident and effective in their ability as teacher leaders. Some sample quotes include:

After this year I feel that I am more confident in my understanding of the importance of the MSTI. I have always known that the MSTI is engaging for students, but when coupled with the 5E's of Learning it is a powerful approach. I feel that because of my understanding I am now better equipped to lead other teachers in using this approach. I also feel that this year has helped me to communicate with teachers about areas to improve or strengths that they may want to share with their grade levels.

I gained a mountain of knowledge through research and Professional Developments. I was able to help teachers implement the current research and trends in Math in the classroom and actually saw growth in the students.

I have a deeper appreciation of MSTI and the role that it plays in schools and in the lives of children. I was very naive about the organization and the support that it provides to schools and teachers. I feel more confident about my ability to work with various people and how to communicate more effectively with others. This job requires the use of good communication skills with teachers and other specialists. It takes confidence in yourself to be able to communicate with teachers about areas of concern and humbleness about what may be uncertain to you.

The learning and the opportunity to delve into current research and truly learn new and innovative things were great. The professional development I received this year was stellar. I also liked getting to design and implement PDs for teachers in schools. It gave me an opportunity to become an "expert" and it gave me great experience as a leader. I loved all of the things I got to do because I really got to learn the Investigations and to get to the "why" these things are taught. I enjoyed going to all of the different schools and seeing what others are doing and for the opportunity to share what I've learned this year.

The MSTI professional development helped the fellows transition from just being a teacher of students to also being a leader of teachers. The opportunity to work with other teachers caused the fellows to strive for a deeper understanding of the content in order to model lessons for teachers, observe specific elements of MSTI lessons, provide meaningful feedback, and have engaging conversations. Fellows learned that professional dispositions were necessary to overcome resistant teachers as well.

Assertion 4. The fellows experienced both personal and professional satisfaction in assisting teachers with modifying their instruction to become more effective in teaching children science and mathematics. At times the fellows were not as successful as they strived to be in leading teachers towards inquiry-based instruction. Being present in classrooms and assisting teachers in modifying their instruction was very rewarding for the fellows. A sense of pride in what they accomplished was evident in their statements. When change occurred in the instructional style of a teacher, a feeling of validation and achievement was noted. The following are examples of participants' responses on this topic:

The most rewarding aspects of being a MSTI specialist was being able to help teachers effectively reach students. Before this year I was in my own classroom teaching MSTI, but I don't think I was questioning how I should have been for my students to be able to retain and recall the knowledge. I wish I had someone come in and show me how to effectively question my students so that they were problem-solving and critically

thinking. I also enjoyed being able to meet so many teachers and build new relationships with them and principals. When working with seasoned teachers it is hard to influence them towards a new way of teaching and it was nice to see some of them embrace the 5E's and give it try.

The most rewarding aspect was hearing a teacher change her way of thinking about teaching science. As scary as it sounds, there are teachers out there who receive kits and never open them. It is so wonderful when they see the benefits of completing the investigations with their students. A support cycle without evaluation or judgment is a vital part of the MSTI training.

In coaching a teacher, with focus of the model lesson being on questioning, the teacher realized that she told the students too much and tried to push them to what she wanted them to think. We were actually in the "explain" part of the lesson and the student was demonstrating his learning under the document camera. The teacher proceeded to tell the student what he was thinking. I touched the teacher as a gentle reminder, and she then allowed the student to finish his explanation. As he concluded, the teacher responded that his explanation was unique, and she had never thought of the element in that way. Now, she realizes I ask questions to help the students to begin to think and allow them to explore different options. I left that room with a smile on my face and with this quote in my head. "Listen, don't just wait to talk" (Donald Trump)! The true meaning of reform is the change in instruction. She is now on her way to changing her instruction in Math and all the other subjects she teaches.

One of the most rewarding aspects of being a MSTI specialist is that I got to work and change the way that teachers teach and help students talk, think and explore mathematically. I love changing the lives of children and it is ALL ABOUT THE KIDS!!!! I loved sharing ideas with teachers, planning, and implementing the lessons we planned together in their classrooms. I found it to be very rewarding to see teachers trying a new approach to teaching with hands on inquiry-based thinking.

The most rewarding benefits of being a coach was to be involved in the lives of children. I have worked with a summer camp that uses MSTI math and science. It was incredible for me to coach at a school where many of the students from the summer camp attended. I was able to see how MSTI had impacted their education and the learning that took place in the summer was carried over into the school year. I also enjoyed working with teachers and sharing ideas. It was also indescribable to see teachers change their way of teaching, even if it was only a small step. It made me feel as though they care enough about their children to try a new approach.

Success for fellows came when they felt they made a difference with a teacher. They realized their impact was far reaching if a teacher had a paradigm shift; the lives of many students were impacted, both immediately and far reaching. Though the fellows acknowledged the difficulties with resistant teachers, they shared their resilience and commitment to continuing efforts to transform a school one teacher at a time.

Meaningful Fellow Classroom Teacher Relationships

The fellows' post experience discussions centered on the relationship formation established with the teachers they served. Each participant suggested that it was important for a foundation of trust to be established before progress could be made with assisting a teacher. Teachers had to feel safe

in knowing that the fellows were not in their rooms to evaluate them but instead were there to observe them in order to assist and coach them in improving instructional strategies. Some classroom teachers were resistant to the assistance offered, while others embraced them once a foundation of trust was established. Professionals like to be viewed as competent in the presence of other professionals, and teachers are no different in this regard. Some teachers were more guarded in order to defend themselves against the perceived threat of another professional thinking negatively about their instructional methods. Teachers had to believe that inquiry-based instruction using MSTI was beneficial in providing better instruction for their students. Most importantly, teachers had to believe that they were capable of implementing the desired teaching strategy (Putnam & Borko, 2000). Typically, once that foundation of trust was established, the fellows were successful in assisting teachers. Fellows felt both accomplishment and frustration in assisting teachers and developing these relationships for many reasons as is expressed in their statements.

Two assertions emerged from this theme in relation to the fellows' perspective as they discussed teacher leader/teacher relationships: (a) Fellows had to support and validate teachers' feelings of insecurity to establish a relationship of trust to challenge teachers to take the risk of varying from their normal instructional methods, and (b) fellows experienced both personal and professional failure when they were not able to convince teachers that inquiry-based teaching was a more effective instructional strategy in science and mathematics.

Assertion 1. Fellows had to support and validate teachers' feelings of insecurity to establish a relationship of trust to challenge teachers to take the risk of varying from their normal instructional methods using MSTI.

Although teachers served by the fellows taught in MSTI schools and received MSTI instructional material, many had not used any of their resources in teaching science or math. Their method of instruction was strictly direct instruction where the students were not actively engaged in learning. The teachers' pre-existing framework and belief system about the manner in which science or math should be taught was deeply entrenched in their minds. Many of the teachers who received assistance had been using direct instruction for years and were apprehensive about changing their way of instruction. The fellows struggled with some teachers in trying to change their perspective on inquiry-based teaching and found it particularly challenging to influence seasoned teachers. Modeling by the fellows was effective in convincing teachers to engage in new instructional methods for the benefit of all students. The following are examples of participants' responses on this topic:

One of my teachers was nice but said that she did not have time for this type of support and stated that she was not planning on changing her method of teaching. I talked to her and I explained that I was a teacher and I understood the demands she was experiencing. I asked her to give me a chance and that I was just like her, I was not there to criticize or evaluate in any way. After the model lesson, we had a conference to discuss the lesson. The teacher told me that she had never taught inquiry because she was afraid to relinquish control and because she did not understand it very well. I said that quite a few people feel that way and it was not uncommon. After that moment, she and I had a relationship. She felt comfortable with me in her room and she tried new things. Before her solo lesson began, she turned to me and said, "I may mess this up, but I am trying." I told her that she was doing great and I would help her any time she needed me. She did an awesome job on the lesson and the kids loved it. It was a small step for the teacher, but it was a change. I know that she and I will always have an open relationship. On my last day, she approached me and said,

"You were right, I can do this and I am doing it because you did not make me feel ignorant or unable to do it."

I had a teacher who was embarrassed because she did not want me to know how little she had used her kit. I believe that by not judging her and letting her know that I truly wanted to help her, she came a long way. I tried to validate what she had done and encouraged her to go even further. By celebrating these small victories she gained a confidence that she did not seem to have before. When she expressed fear about the solo lesson, I told her we would just do it together! We did and she loved it. She saw what a difference it made for her kids.

At one particular school I had to work miracles to get the first grade teachers just to open the investigations and start using manipulatives. After modeling a lesson and team teaching one teacher stated that she noticed a difference in her student's thinking and how excited they were when it was time to teach math. What she said was contagious because the other teachers wanted to know what she was teaching and they couldn't wait for me to help them with their solo lessons. They also asked me to come and model additional lessons for their students. These first grade teachers also asked for additional help with intervention and organizing materials in their classrooms. They were so grateful for the New Investigations and the mini training sessions on the Investigations. They loved the 5E model of instructions and were excited about using it in their classrooms. I told them to remember that it's all about the kids.

It is sometimes challenging to influence seasoned teachers to implement new ways of teaching. I had a teacher who had been teaching for 20 plus years and she was skeptical about using MSTI and the 5E's of learning. After I modeled for her she was more willing to try her lesson and made comments such as, "After watching you I think I might be able to try it." I reassured her that I would be doing the lessons with her and she could try one part at a time with more than one lesson if need be. Part of the cycle involves helping teachers find resources to use for engagement. The teacher and I talked about checking out a book from the library and maybe some videos about bees and pollination. After our meeting I saw her later in the hall with a stack of books. I asked her if she needed help and she was so excited to show me that she had found a class set of books in the library on the subject of bees and pollination. We looked through the books and decided she could use it for several days and many lessons. She really appreciated the help and I could tell she was starting to "change" her teaching style. I thought this was a success story seeing as when I initially started the cycle I was having to open her kit and show her all the materials and how to use them.

The fellows learned valuable lessons about coaching their peers. They learned that most often, teachers want to do a good job and do what is best for their students. Generally, teachers are not resistant to change for the sake of being resistant, but more often because of their own insecurities. The fellows learned how to coach teachers through a side-by-side approach rather than by simply *telling* them what changes needed to take place. The success the fellows experienced with these resistant teachers allowed them to grow professionally in new dimensions. They had to learn "they should not try to convince ambivalent or reluctant teachers through moral exhortation and research evidence. Instead, they prove that [their students] can learn by helping teachers actually do it. It is after [this] is accomplished that teachers' moral purpose shines and becomes a huge energizing resource" (Fullan, 2010, p. 15).

Assertion 2. Fellows experienced both personal and professional failure when they were not able to convince teachers that inquiry-based teaching was a more effective instructional strategy in science and mathematics.

At times the fellows were not able to form the necessary relationships needed in order to convince teachers that inquiry-based teaching was an effective instructional strategy. Interestingly, the fellows, as teachers themselves, often could relate to why teachers were not willing to try something new. Many times the fellows blamed their own inexperience to the position when they were unable to transform some teachers' instructional strategies. At other times, they saw how individual schools' organizational structure or school district mandates made it difficult for any teacher to use MSTI inquiry-based teaching and meet their mandated goals. The fellows felt they needed more time to motivate teachers and model effective inquiry-based teaching. Because of their caseload, time was limited to collaborate with their assigned teachers. The following are examples of participants' responses on this topic:

Most barriers come from teachers not wanting to teach outside of their comfort zone. Many seasoned teachers do not want to try new strategies if their scores are good enough to begin with. The MSTI also takes time to implement and many teachers complain about time in the classroom. Teachers are worried that by teaching MSTI they are not covering all of the standards for the state tests. What I try to do is show them how the lesson correlates with the COS. As far as time teachers need to realize the more they use the materials the more familiar they become with it and are able to incorporate their own shortcuts and techniques. In addition, teachers should be able to save their plans over the year and use them over again with a few adjustments.

I did have some teachers that I felt would not use MSTI after I left. That made me feel like I failed their students. I guess I learned that the implementation of MSTI to fidelity in a school requires the sincere commitment of a school's administration and faculty.

Some of the barriers are that teachers feel they cannot use MSTI due to the pacing guides, testing, and other mandates set forth for them. It is so difficult to show teachers how to incorporate this type of learning and that you can achieve the results you want. It is hard to show in 3 lessons the type of thinking skills that can be developed through inquiry learning that will allow students to use the information they know and apply to new situations such as a state test.

A personal barrier that I encountered was not enough time to read the necessary literature to build my professional toolbox to my expectations. I also had to use an excessive amount of time to learn how MSTI supported the curriculum to the point I felt comfortable to deliver it to the students and have adult learners observe. Professionally, I felt that I did not stay in a school long enough to make a major impact on the reform in instruction for the entire school. Some teachers need to repeat the cycle several times to feel confident in their implementation.

Time, time, time. No one wants to give up their planning time to meet with you. Teachers are too stressed and have too much else to do. Most everyone always accommodated us but they weren't always "there" 100%.

TEST...TEST...TEST.... TEST... The American school system is all about the test. The teachers live in a culture of fear about the test. They are so busy digging with the shovel (direct teaching) that they have trouble seeing the backhoe (MSTI).

Fellows perceived teacher resistance to come from a variety of sources that included: teachers' fear of change, lack of knowledge for inquiry-based instruction or content knowledge, or limited time to deviate from drill and practice to prepare students for high-stakes tests. The fellows reflected on their concerns and collaborated with their cohort members and mentors to develop strategies to reach the uncompromising teachers.

Discussion

Implications

Teacher leaders are needed if meaningful and sustainable change is to happen within schools, as they can be instrumental in a school system's ability to improve student achievement and teacher job satisfaction (Hanuscin, Carina, & Somnath, 2012; Rhoton & McLean, 2008). Institutions of higher education must partner with school systems to structure opportunities for preservice candidates to work under the tutelage of teacher leaders. This will allow the preservice candidate an opportunity for collaboration while learning their craft and to also learn the additional benefits of developing into a teacher leader.

Teachers are necessarily at the center of reform for they must carry out the demands that accompany high standards in the classroom (Cuban, 1990). To satisfy these demands, "teachers must be immersed in the subjects that they teach (content) and have the ability to communicate basic knowledge to develop advanced thinking and problem solving skills (pedagogy) among their students" (Garet et al., 2001, p. 916). However, though many teachers generally support high standards for teaching and learning, many are not prepared to implement teaching practices based on these standards (Cohen, 1990; Elmore & Burney, 1996), nor are they prepared to lead other teachers. Institutions of higher education can offer learning opportunities to strengthen content knowledge while simultaneously developing teacher leadership skills through teacher leader Master's of Education coursework.

School districts and local school administrators must recognize the value added of teacher leadership, ultimately on student achievement. Along with a strong commitment to the coaching process, teacher leaders must possess the knowledge, skills, and dispositions needed to support classroom teachers' effectiveness with all learners. Given today's high stakes testing environment, many teachers continue to use a model of teaching and learning that focuses heavily on memorizing facts without emphasizing learning for deeper understanding of subject content and processes (Darling-Hammond & McLaughlin, 1995). Many teachers are simply reluctant to try different forms of teaching that may be more effective. If supported by administrators, teacher leaders can assist with this problem. Administrators can structure opportunities for teacher leaders to improve problem situations by focusing teachers' commitment and energy in an organized fashion to realize a desired outcome (Rhoton & McLean, 2008; Fullan, 2007; Suescun, Romer & MacDonald, 2012). Teacher leaders are proven content teachers who willingly coach their peers and are focused on improving instructional practices in effort to improve student learning (Carpenter & Sherretz 2012; Klentschy, 2008). Creating

opportunities for enhancing learning are not achieved by the mere physical existence of schools, but rely on the quality of teaching and learning that takes place in them.

Limitations

As with all research studies, there are limitations that should be acknowledged. In this study, one of the instruments used to collect data was a survey that was completed through self-report of the participants. With survey research it is always a possibility that participants could potentially misrepresent their actual perceptions of their experiences, and the design of the open-ended questions may not accurately reflect participants' perceptions. In addition, it is possible that the participants did not give fully accurate or complete answers during the individual interviews. The participants in this research were selected as fellows in the program; therefore, a convenience sample of participants was used, thus, limiting the generalizability to a larger population. Conducting the study with more participants would strengthen the study's design. Finally, it may be beneficial to conduct a longitudinal study examining the impact of the fellows once they return to their home school, both on the student achievement and the implementation of MSTI with the faculty they coached.

Educational Importance and Conclusion

Teacher leadership is an essential component in building-based educational reform efforts focusing on student achievement (Hanuscin et al., 2012). Ultimately, the MSTI Fellows program is working toward creating, as defined by Patterson and Patterson (2004), teacher leaders who work with their peers for the sole purpose of improving teaching and learning.

The professional development activities that the fellows were involved in occurred in an authentic context. According to Brand and Moore (2010):

> Too often, professional development activities are based on a training approach in which teachers are presented with ideas and are expected to return and duplicate them in their classrooms (Howe & Stubbs, 1997). In many cases, these PD experiences result in little or no use of the instructional ideas and no visible change in students' learning. According to Garet, Porter, Desimone, Birman, and Yoon (2001), effective staff development emphasizes understanding the subject matter to effectively respond to the demands for higher standards. Garet et al (2001) found that PD is effective when it is sustained, consists of hands-on applications of content, integrated into teachers' daily responsibilities, and involves group participation. Kimble, Yager, and Yager (2006) attributed active involvement and constructivist-based PD over a sustained period as factors leading to prolonged implementation of constructivist-based practices. (p. 3)

Many teachers are not prepared to serve in leadership roles, much less to implement advanced content standards (Cohen, 1990; Elmore & Burney, 1996). However, the MSTI Fellows program avoided this pitfall through its one year sustained professional development in that the fellows continuously repeated the process with different teachers during their fellowship year. They had the opportunity to keep revisiting key concepts, and in doing so, they gained more experience and grew as teachers and teacher leaders. The yearlong experience gave each fellow the chance to "confront, connect, and reconcile new knowledge with prior beliefs and experiences" (Brand & Moore, 2010, p. 19). Each day the fellows had the opportunity to reflect on the experiences of what strategies worked

or did not work with one teacher in order to be more effective with the next teacher they were to assist. Through this experience they had the opportunity to fill content knowledge gaps and build the skills needed to be effective teacher leaders.

The teachers who participated in this study described their experience as very positive. Teachers indicated that they had tremendously improved their knowledge base and gained a better understanding of inquiry-based teaching and learning. In the process, the teachers improved their content knowledge by the mere fact that they had to study to become proficient in assisting other teachers within a short period of time. During their development as teacher leaders they learn to master many tasks including observations of classroom teachers, reflection time, assessment, collaboration, and action plans. Because the learning curve was so steep, the selection of the participants was of the utmost importance. Fellows who had previous experience with inquiry-based principles using MSTI transitioned more easily into their new teacher leader positions than those fellows without previous experience.

In conclusion, this study explored the effect of a professional development teacher leadership training program on the pedagogical and content development of math and science teacher leaders. The educational importance of this program is found in its intent to inform the world of Science, Technology, Engineering, Mathematics (STEM) education of the transformative relationship between how science and math teacher leaders are trained and their perspectives of that training. The data presented indicated that effective teacher leaders at the very least must possess the following characteristics: (a) they must be an effective teacher with strong pedagogy and content knowledge, (b) they must have the ability and confidence to work with adults learners no matter the experience level of the adult they are assisting, (c) they must have good communication skills that include the art of being able to listen and question in order to lead the assisted, (d) they must always remain humble, (e) they must understand their own growth needs for improvement and be comfortable in seeking assistance to address their needs to become more effective as both a teacher and a leader of teachers, and (f) they must always be willing to learn from others.

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