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ABSTRACT: This paper outlines a University-School District partnership with the intent to increase the number of middle grades mathematics and science teachers. This externally funded initiative includes on-site, authentically situated professional development for pre- and in-service teachers at three different urban, low-socioeconomic schools with a majority Hispanic population of students. Program objectives include increasing mathematics and science content knowledge, increasing self-efficacy in teaching math and science, building and incorporating a success-driven school culture and infrastructure to increase student performance in a well-articulated, scalable and transformable model. Program components include site based common planning times, STEM Thursdays where science and mathematics lessons are practiced and refined, authentic summer research opportunities for pre- and in-service teachers to work with scientists and university faculty, teacher certification workshops and a mentoring model that includes program graduates and pre-service teachers. First year results show that the program had a positive impact on the teachers' self-efficacy and outcome expectancy as their scores significantly increased after participation in the project. Key elements in the model included (1) a strong partnership between a school district and institution of higher education, (2) a unique collaboration between mathematics and science educators and scientists, pre-and in-service teachers, (3) a professional development and mentoring program designed around the school district's adopted course of study and the NSES, (4) the integration of community resources, (5) a partnership with preservice and inservice teachers and district administrators with science and mathematics higher education faculty, (6) the development of teacher leaders, and (7) a comprehensive evaluation program.

NAPDS Essentials Addressed: #1/A comprehensive mission that is broader in its outreach and scope than the mission of any partner and that furthers the education profession and its responsibility to advance equity within schools and, by potential extension, the broader community; #4/A shared commitment to innovative and reflective practice by all participants; #7/A structure that allows all participants a forum for ongoing governance, reflection, and collaboration; #8/Work by college/university faculty and P–12 faculty in formal roles across institutional settings; #9/Dedicated and shared resources and formal rewards and recognition structures

Introduction

Middle School Mathematics and Science Teacher Shortages

There is a critical shortage of middle school STEM (Science, Technology, Engineering and Math) teachers, especially in low income and high minority schools. Contributing factors include teachers' inadequate science content knowledge and a principle focus on language arts that limits the time for other projects in the early grades (Marx & Harris, 2006). Fewer than half of elementary teachers have completed the minimum number of recommended science courses and many elementary school teachers hold significant misconceptions regarding science (Capps, Crawford, & Constas, 2012). The lack of focus on science and science teaching as well as the lack of preparation in science content helps explain why science is not integrated with other content areas such as literacy or mathematics, and why strategies that engage children in the process of inquiry are not common (Capps et al., 2012; Gillies & Nichols, 2015).

Improving Teacher Preparation in Mathematics and Science

Research suggests that young children should be given active engagement opportunities where they think of science and mathematics as a meaningful and worthwhile enterprise and view themselves as scientists and/or mathematicians (NRC, 2012). In order to view math and science as meaningful and feel competent in these subjects, young children need to be involved in experiences that involve mastery, positively contributing to the students' self-efficacy (Bandura, 1997). However, the current paradigm that is embraced by the majority of educators uses the scientific method in a linear fashion which often allows the proliferation of distorted images of scientists. Teachers are often conducting science and mathematics activities without understanding the process behind those activities (Windschitl, Thompson, Braaten, & Stroupe, 2012). Mathematics teachers need mathematical knowledge that extends beyond an understanding of mathematical procedures. To make mathematics teaching more conceptual and less procedural, mathematical professional development must address teacher's dimensions of mathematical knowledge rather than focusing only on pedagogy or generic teaching skills (NCTM, 2010). In addition, research tells us we must engage learners deeply with science content while using authentic science practices (NRC, 2012). The following professional development project and associated research study explains one way we can engage preservice teachers (PSTs) more deeply in scientific and mathematical thinking for teaching and learning.

Exposing Preservice Teachers to Authentic Science and Mathematics Research

What is missing in current professional development (PD) is the investigation and exploration that is involved in authentic science and mathematics research, such as framing a valid research question, rigorous and sometimes sophisticated data collection, consistent questioning throughout the process where the activity both generates and validates knowledge that is not necessarily a step-wise, linear progression (Ingersoll & Merrill, 2011). Authentic science can best be experienced by conducting authentic, testable, revisable, explanatory and generative research in authentic settings that include an active-learning modality (Windschitl et al., 2012). However, elementary teachers are rarely given the opportunity to work with scientists and mathematicians to learn how science and mathematics is conducted. The Elementary Teachers Engaged in Authentic Math and Science (ETEAMS) project investigators believed that authentic science and mathematics investigations can best be explored and experienced by participating in real research performed by researchers while including this investigative research element in the PD model. This research report describes a model where elementary preservice teachers receive professional development in teaching conceptual mathematics and science. This model involves not only teaching and learning in the elementary and middle school classroom, but also participation in authentic research (real research being conducted for data analysis and subsequent publication) with mathematics and science university faculty.

The ETEAMS Initiative: Developing a Model for Professional Development

What Should be Included in Professional Development?

Since the mid-1990s, a collaboration between the largest school district and Texas A&M University-Corpus Christi (TAMUCC), a Hispanic-serving institution (HSI) and has developed into strong K-12 teacher preparation partnership. Starting in Fall 2013, the school-university partnership began implementing the externally funded ETEAMS program at three participating schools, including one middle school and two elementary feeder schools serving a combined 1,900 students annually. TAMUCC investigators decided to create a new model for science and mathematics content instruction by incorporating site- and content-specific professional development with field basing, a semester long course where PSTs spend two full days a week for the semester in elementary and middle schools observing classes and assisting with teaching and lesson planning. The PD model incorporates inquiry, capacity building, professional team building and other tools to increase authentic site-based teaching where PSTs are in active teaching and learning situations.

Professional development should connect teachers to external expertise while encouraging teachers' discretion and creativity and should be sustained and continuous, rather than episodic and lacking follow-up (Cochran-Smith & Lytle, 2009). By improving teaching instruction with sustained and continuous PD, improvements in motivation, job satisfaction and efficacy in teaching increases which leads to improvements in teacher performance (Ingersoll & Merrill, 2011). After a thorough review of research regarding teacher preparation in mathematics and science, investigators determined that PD workshops would focus on the implementation of research-based instructional practices that involved active-learning experiences for participants, and provide opportunities to adapt the practices to the specific classroom subject matter and situation.

Additionally, investigators agreed that the ETEAMS PD experience should try to increase capacity building at the school. Capacity is a multi-faceted blend of motivation, skill, positive learning experiences as well as conditions and culture within the organization and its infrastructure (Stoll, Bolam, McMahon, Wallace, & Thomas, 2006). According to Ingersoll and Merrill (2011), teachers need to be involved as active partners in their own professional growth instead of feeling like PD is something done to them, not something done for them. Collaboration with colleagues can spark the need for teachers to explain their practices and articulate rationales for instructional decisions (Opfer & Pedder, 2011). Capacity building, therefore, should be designed to fit the specific capacity needs of a school at a particular point in time while also considering how the integration of program mandates and incentives for innovation will promote focused and sustained school improvement (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; National Association of Professional Development Schools [NAPDS], 2008).

Another problem that often arises within university-sponsored teacher education programs has been the lack of connections between campus-based teacher education courses and field experiences, that is, observations in the classroom, student teaching experiences and other experiences that occur in the public school classroom (Zeichner, 2007). Future educators should be actively engaged in the school community (NAPDS, 2008; National Council for Accreditation of Teacher Education [NCATE], 2010), yet they rarely leave the university to practice teaching until the student-teaching experience. In addition, student teacher instruction and practice should be followed by reflection and feedback (Guskey & Yoon, 2009; NAPDS, 2008). Darling-Hammond (2009) identified this lack of connection between college education courses and field (public classroom) experiences as the Achilles heel of teacher education. PSTs typically are left to work by themselves with little if any guidance in relating what they are doing to campus courses, and it is often assumed that good teaching practices are personally identified as they occur, rather than taught in an authentic context (NCATE, 2010).

Engaging preservice and inservice teachers in authentic practices of mathematics and science teaching is also important because it provides a productive context to learn about the nature of science (NOS). By embedding PD in practical activities, the PD can create conditions for growth in teachers' professional knowledge through "situated cognition" (NCATE, 2010). Higher achievement levels in schools with positive professional communities were attributed to teachers who focused on higher quality thinking, deep content knowledge and connecting the classroom with the world outside (Louis & Marks, 1998).

Challenges in Incorporating Authentic Classroom-Based Professional Development

While engaging in authentic teaching using authentic practice is important, meeting expectations regarding instructional pacing and ensuring students' preparedness for state assessments within a tight time frame can be major concerns (Certo, 2006; NCATE, 2010). Districts have adopted specific curricula and restructured student schedules to implement reform efforts causing teachers to experience competing demands between content coverage and comprehension. Support is required to deal with this predicament. PD experiences must focus on helping teachers understand how to close gaps between the standards and the content and nature of their own instruction. Mathematics standards, for example, may call for students to make conjectures regarding algebraic concepts, but often teachers address algebraic concepts by requiring students to memorize key algebraic properties and demonstrate proficiency in performing algebraic procedures, creating a gap between what the teacher does in the classroom and what the standards require the students to learn (Porter, Smithson, Blank, & Ziedner, 2007). Since standards-based accountability emphasizes the alignment of standards, instruction and assessments, PD that is responsive to accountability should involve shared decision making among participants when addressing these challenges (Lumpe, Czerniak, Haney, & Beltyukova, 2011; NAPDS, 2008, NRC 2012).

Planning the ETEAMS Initiative: Vision and Program Components

The ETEAMS program vision includes the development of an inclusive community of learners in which preservice and inservice elementary teachers and underrepresented adolescents build STEM content knowledge, have authentic STEM experiences and build positive beliefs and favorable dispositions that are needed to support achievement in STEM teaching and learning. The key components of the ETEAMS program were driven by the commitment to an ongoing and reciprocal PD for all participants guided by need (NADPS, 2008). All three of the partner schools were in "Improvement Required" status (students failed to meet minimum test scores on State standardized exams) according to NCLB when this initiative began. Therefore, there was an identified need for research based strategies to improve competencies in mathematics and science teaching and learning at these partner schools.

TAMUCC's ETEAMS initiative is funded by a 3-year grant to test an innovative preservice strategy for bolstering the number of elementary to middle level STEM certification and teaching pathways, assisting them with the certification process by augmenting their STEM content knowledge. The program provides empirical evidence on early career fellowships aimed at increasing the preservice elementary-to-middle-school-STEM pathway. The key program components include utilizing the existing strong partnership between a school district and TAMUCC and includes a unique collaboration between mathematics and science educators and scientists, pre- and inservice teachers. A professional development and mentoring program is designed within the school district that utilizes the adopted course of study aligned with National Science Education Standards. In addition, the ETEAMS program created a partnership with preservice and inservice teachers and district administrators with science and mathematics higher education faculty to strengthen the development of teacher leaders. In addition, the investigators created a comprehensive evaluation program. As a research-based effort, investigators are studying the impact of the ETEAMS initiative through a mixed methods matched-group research design addressing grades 4-8 students, pre- and inservice teachers, school, district, and university outcomes in relation to views on the nature of science, as well as self-efficacy, interest, and achievement in STEM, and indicators of the quantity, quality, and diversity of grades 4-8 mathematics and science teachers. The following outlines the objectives of the ETEAMS program study.

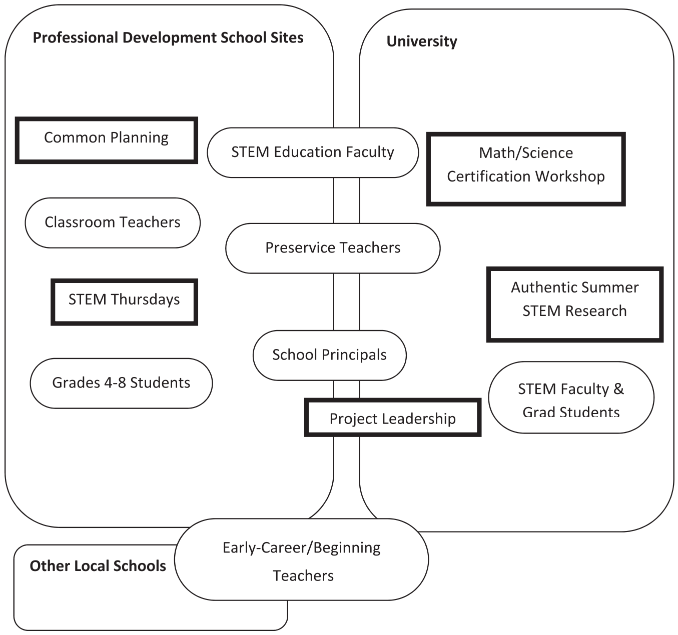

Figure 1. Organizational Structure of Professional Development School Fellowship Program

NOTE: Rectangles indicate major activities, ovals indicate participant groups, proximity of ovals to rectangles suggests typical level of involvement.

ETEAMS Program Objectives

Given the concerns outlined, the ETEAMS program includes a number of program objectives designed to evaluate the progress and effectiveness of the partnership implementation. First, ETEAMS sought to improve the quantity, quality and diversity of the middle level STEM teacher workforce serving high-need schools in the local area. Second, to increase grades 4-8 STEM participation, interest, self-efficacy and content knowledge among students and teachers in partnering schools. This would be accomplished by developing a well-articulated, scalable and transformative model of preservice teacher preparation for elementary teachers to become middle level STEM teachers. Lastly, investigators sought to contribute to research literature on STEM teaching and learning and also K-8 teacher preparation program development.

The ETEAMS initiative is an effort to increase both the quantity and quality of middle grades math and science teachers by placing PSTs with classroom teachers to guide them in their field basing and student teaching experience and creating dedicated time for common planning between inservice and PSTs as well as TAMUCC faculty. These STEM faculty are on site to help preservice students plan and implement exemplary STEM lessons. The initiative also provides an authentic summer research experience and offers certification workshops to prepare students for Praxis/qualifying teacher certification exams. Figure 1 illustrates the organizational structure that was designed for the PD school fellowship program model in the ETEAMS initiative:

ETEAMS Program Goals and Evaluation

Quality of Instruction

The ETEAMS initiative improves the quality of grades 4-8 STEM instruction by deepening preservice elementary teachers' content knowledge in middle levels science and mathematics. In addition, ETEAMS establishes institutional supports for evidence-based practices in STEM education such as vertically aligned instruction across school campuses and integrated STEM curriculum. The initiative also engages preservice teachers, classroom teachers, and grades 4-8 students in authentic STEM research processes, increasing teacher quality.

Quantity of Teachers

The ETEAMS program increases the quantity of grades 4-8 STEM teachers both by supporting more initial certifications of middle levels mathematics and science teachers and by including support to increase retention of early career grades 4-8 STEM teachers. ETEAMS fellowships will directly lead to a total of 90 newly certified middle levels STEM teachers over a 3 year period, at least half of which are expected to teach in high-need schools. In addition, retention efforts are expected to reduce local hiring difficulties and stabilize local middle levels teaching staffs.

Diversity of Teachers

The ETEAMS school district is a large district with low socioeconomic, high minority student population in which the majority of both students and teachers are of underrepresented ethnicities in STEM professions. Local district students are 77% Hispanic, 15% White, 5% African American; local district teachers are 52% Hispanic, 44% White, and 3% African American. TAMUCC students are 43% Hispanic, 42% White, 5% African American, and 5% International. Through recruiting and responsive program design, ETEAMS investigators estimate a total of over 50 Hispanic fellows will graduate the ETEAMS program prepared for middle levels STEM teaching careers.

ETEAMS Key Program Features

Challenging Courses and Curriculum

The ETEAMS initiative coordinates a selective, cohort-based middle levels STEM teaching fellowship program for preservice elementary teachers. Fellows are Senior generalist elementary education majors who have completed at least 3 of the 5 required content-based courses in mathematics and science and will be financially supported as they participate in fellowship activities for up to 3 years. Table 1 outlines the goals and objectives for the ETEAMS fellows.

Beginning in summer, and continuing into the academic year, fellows collaborate with inservice teachers, mathematicians,

Table 1. Goals for ETEAMS Program Fellows

	Goals	Program Implementation
1	Participate in Authentic STEM Research.	Examine beliefs on the nature of science while contributing to authentic university STEM research.
2	Engage in Middle Levels STEM Teaching.	Augment classroom teaching experience with family learning events and peer-assisted instruction with grades 4-8 students.
3	Build Pedagogical Content Knowledge.	Participate in a grades 4-8 mathematics or science workshop, passing the related certification exam.
4	Collaborate with Inservice Teachers.	Contribute to teacher-led grades 4-8 STEM teaching reform and support evidence-based instructional practices.

scientists, and science graduate students on original scientific research projects. Research teams synthesize research results and generate related classroom activities that are shared through a new educational website, eteamscc.com. Then, cohorts complete extensive field-based preparation for grades 4-8 STEM teaching by participating in an augmented professional development school partnership. Preparation includes half-day common planning between pre- and in-service teachers and development of web-based STEM instruction materials. Finally, participants complete one of two certification exam workshops taught by STEM education faculty on the content and discipline specific pedagogical knowledge required for earning grades 4-8 mathematics and science certification. Table 2 outlines the partnership goals and outcomes of the ETEAMS initiative:

Much of the ETEAMS research data uses instruments and protocols from recent research, and the research design employs several existing instruments with published analyses of delimitations, reliability, and validity. Teachers' self-efficacy in mathematics and science are measured through annual administrations of the Science Teaching Efficacy Belief Scale (STEBI) (Enochs & Riggs, 1990) and the Mathematics Teaching Efficacy Belief Instrument (MTEBI) (Enochs, Smith, & Huinker, 2000), each of which includes subscales for outcome expectancies and self-efficacy (see Bleicher [2004] for structural analysis, reliability, and validity). Fellows and teachers' growth in pedagogical content knowledge in mathematics or science are measured through normalized gains on existing pre- and posttests developed for the mathematics and science workshops, as well as scores on the TExES mathematics 4-8 and TExES science 4-8 certification exams. Views on the nature of science are measured by the VNOS-C survey (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002).

Implementation of mathematics and science instructional practices is assessed using composite scores from classroom observations by ETEAMS staff and self-reports on the Survey of Instructional Practices (science, math, and administrator forms) from the Council of Chief State School Officers and the Wisconsin Center for Education Research (with support from grant agency). Data on the quality, quantity, and diversity of middle levels STEM teaching workforce in the local school district and surrounding areas comes from internal application and hiring records, state records on teacher education programs, and administration of the SASS teacher and principal follow-up surveys (NCES, 2010).

Table 2. ETEAMS Partnership Goals and Outcomes

	ETEAMS Partnership ***Goals***	
1	Prepare preservice elementary teachers for middle levels STEM teaching.	Implement a new teaching fellowship program for generalist preservice elementary teachers to become middle levels STEM teachers.
2	Support grades 4-8 STEM teaching and learning	Provide rich experiences for grades 4-8 students and teachers to explore the nature of science and mathematical problem solving.
3	Facilitate authentic STEM research collaborations	Coordinate scientists, teacher education faculty, and school teachers in content-based scientific research projects.
4	Lead sustainable institutional change and innovation	Implement, articulate, and share an innovative model for preparing middle levels STEM teachers.
	ETEAMS Partnership ***Outcomes***	
1	Middle levels mathematics and science teachers.	Improved quantity, quality, and diversity of middle levels mathematics and science teachers in high-need schools.
2	Middle levels STEM engagement and achievement.	Increased STEM participation, self-efficacy, interest, and achievement among grades 4–8 students and teachers.
3	STEM teacher preparation design and development.	A well-articulated, scalable, and transformative model for middle levels STEM teacher preparation.
4	STEM Education Research	Evidence-based contribution to STEM teaching and learning and K–8 teacher preparation literature.

Recruitment and Placement of ETEAMS Fellows (Preservice Teachers)

The ETEAMS initiative recruits cohorts of eighteen PSTs in late fall and in late spring. The recruitment and selection of ETEAMS cohorts takes place in conjunction with the early childhood through grade 6 (EC-6) generalist elementary education majors' field placement process. Class announcements and recruitment handouts are provided in math and science preservice content courses. Those students with demonstrated success and interest in STEM content are invited to apply and complete a contract to work and complete program assignments and responsibilities.

The preservice teachers (PSTs) participate in the ETEAMS program during their required year-long field experience, the final year of their teacher preparation program. The PSTs are then placed in one of three (two elementary and one middle grade) partner schools. During their first semester, they attend partner schools two days a week for their field basing experience (on site observation and teaching) and during the second semester, they complete their traditional five days per week student teaching assignment. There are two designated inservice teachers per grade level (4-8) at each partner school. The inservice teachers participate in common planning, contribute to the planning of STEM Thursdays, and collaborate with the PSTs over the summer in the authentic research experiences.

Site Based Common Planning

Each semester, administrators and project personnel at the three ETEAMS school sites designate two half days devoted to the development of integrated math and science lessons. These common planning times allow math and science inservice teachers across grade levels to work collaboratively with the PSTs. Special education teachers are also included in these planning sessions, with attention brought to ways of differentiating instruction to meet the needs of the diverse learners.

The development of these lessons begins with the state mandated Texas Essential Knowledge and Skills and the school district's Scope and Sequence. The lesson plans are structured utilizing the Biological Science Curriculum Study (BSCS) 5E Instructional Model (Bybee, Taylor, Gardner, Scotter et al., 2006). Briefly, this research-based instructional model has five elements. First, the Engagement phase helps to identify prior knowledge, making connections between the past and present learning experiences. In the Exploration phase, students are given a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. In the Explanation phase, students' attention is focused on a particular aspect of their exploration activity, providing opportunities to demonstrate their conceptual understanding, process skills, or behaviors. In the Elaboration phase, teachers challenge and extend students' conceptual understanding and skills by applying their learning to a new situation. In the Evaluation phase, students are encouraged to assess their understanding and abilities; teachers can formatively assess the students' progress towards achieving the educational objectives. Implementation of the 5E model is preceded by inservice teachers and TAMUCC faculty sharing hands-on activities, modifying the lessons to meet the needs of the particular group of learners they will be teaching, and refining lessons during after school meetings.

During each common planning session, an TAMUCC faculty member facilitates either a NOS or an inquiry-based mathematical problem solving investigation. Together, the preservice and inservice teachers in mathematics and science encounter mathematics problems as well as science activities that challenge their basic assumptions about STEM learning and teaching. Planning sessions then proceed with discussions about how these activities simulate the work of scientists and mathematicians. Participants are encouraged to discuss and reflect what they learned about scientific and mathematical processes, how they would utilize the activities in their classrooms, and what they would need (materials and further training provided by ETEAMS) to fully implement these investigations with their 4-8 students. Misconceptions are challenged as the group discussed long held beliefs about topics related to the NOS (Abd-El-Khalick, Bell, & Lederman, 1998).

STEM Thursdays

Another key component of the ETEAMS model, STEM Thursdays, impacts all of the stakeholders (pre/inservice teachers, STEM faculty, 4-8 students). Three times per semester, hands-on and minds-on lessons are delivered with many conceived during common planning times. The grant personnel (program director, science, mathematics and education faculty) communicate with classroom teachers in advance of the lesson regarding specific needs of the students and prior knowledge. Integration of math and science content is strongly encouraged. Instruction is primarily delivered to traditional heterogeneous classrooms, but includes a middle school mathematics special education classroom requiring modified curriculum. The STEM faculty collects materials and lesson ideas for an initial meeting with the PSTs after school. Collaboratively planned lessons include assignments for lesson materials preparation and lesson delivery for students who teach in classroom teams. A webpage is created and used as a teaching tool during STEM Thursdays and as a lesson repository, a way to disseminate lessons to other professionals. All lesson components including lesson plans, PowerPoints, videos, and student handouts are linked to these webpages. Students meet a second time to practice teaching the lesson.

There have been twelve middle grades lessons (6-8) and 15 elementary lessons (4-5) developed in two semesters of implementation. Examples of lessons include properties of heterogeneous mixtures and solutions, climate change, mathematical measurement and conversions, fractions, material engineering, genetics, geometry, distance and scale measurements. Since the lessons are team taught several times, the PSTs are able to take turns leading delivery of instruction. After each lesson, an evaluation is completed by the inservice teachers, PSTs, and STEM faculty.

Authentic Research Experience

A unique and critical feature of the ETEAMS model is the authentic research experience. School based science investigations usually occur in a one hour class in a middle grades classroom. Students are often indoctrinated with the belief that there is one, linear scientific method and have little to no understanding about scientific theory, scientific law, and the tentativeness of scientific knowledge (NGSS, Appendix H, 2013). The ETEAMS authentic research experience is designed to help preservice and inservice teachers improve their knowledge about the nature of science, their comfort level with engaging in scientific inquiry, and deepen their knowledge of both scientific content and processes. Students experience how mathematics is used in scientific research through statistical analysis, mathematical modeling of biological data, and computer sciences.

Preservice and inservice teachers in the ETEAMS program engage with scientists at TAMUCC for a minimum of 30 hours during the summer STEM research experiences where participants contribute to original scientific research projects. PSTs work with masters' and doctoral science students in the laboratory and in the field. Mathematicians and science faculty work to collect and analyze data in areas such as blue crab toxicology, fish genetics, and research involving neurobiology and the California sea hare that reveals fear and defensive behaviors at the cellular level.

ETEAMS authentic research experiences naturally lead to new questions, new experiments and new ideas for the classroom. In anticipation of this, the summer STEM research experience includes a summative meeting with STEM faculty, PSTs and inservice teachers which focuses on making connections to the classroom and how the research experiences have impacted participants' views on the nature of science, engineering, mathematics and technology. The participants in the authentic research are required to keep a science journal, publishing two research logs on ETEAM's website that record their experiences in the lab and field as well as questions they have and ideas for creating classroom based lessons.

Science and Mathematics Teacher Certification Workshops

During the semester prior to undergraduate graduation, ETEAMS PSTs participate in one of two workshops designed to help complete the grades 4-8 mathematics and/or science certification exams. Workshops feature biweekly Saturday (science) and after school (math) content instruction, content-focused study materials, and standards-based practice on middle levels mathematics and science content and pedagogy. The grant also pays for the students' testing and certification fees as well as a stipend for their participation in the program.

Mentorship Program

Because understanding teacher retention is a critical issue, following year one implementation, plans include recruiting graduates (first year teachers) that will be both mentors and mentees. These mentors will be assigned to one or two preservice (student) teachers to mentor. They will be asked to communicate with their mentees through email, social media, texting, phone, and/or in person meetings. These graduates include several that are on site at the partner schools sharing ideas, anecdotes, and building personal relationships. In addition, the ETEAMS project manager will serve as a mentor to these novice teachers by conducting site-based observations, giving feedback, providing materials and follow up visits. The mentors will meet with the ETEAMS project manager once a month at the university for dinner and continued PD.

First Year Program Outcomes

Highlighted Quantitative Results

The following are selected highlights from the first year implementation of the ETEAMS program which included 15 fellows. Twelve (80%) fellows earned bachelor's degrees and will take certification exams, five in mathematics and ten in science, while four fellows with take both mathematics and science. Eleven of the twelve fellows have accepted STEM teaching positions. Content mastery increased with a normalized gain of 16% and science content by 14% as indicated on pre/post content tests. Ten of eleven teacher-leaders improved on the RTOP measuring evidence-based STEM instructional practices, with a 57% median normalized gain. Participation in STEM Thursday activities involved over 500 students in grades 4-8 with fourteen teacher-leaders participating in five different STEM Thursdays, two PD/common planning sessions, and about 30 hours each of summer research activities. Standardized testing results indicate that in Grade 5 partner schools, the percentage of students achieving "proficient" status in mathematics increased from 54% to 76% while the comparable annual increase in science was from 42% to 56%. In Grade 8 at partner schools, the percentage of students achieving "proficient" status in mathematics decreased from 71% to 69% and the comparable change in science increased from 52% to 55%. The total contact between STEM Faculty and graduate students with fellows was approximately 1,760 hours, including 1,080 hours of authentic science research experiences, 640 hours of collaboration on STEM Thursdays, and 40 hours of guest instruction in science certification workshops. In addition to these promising results, school administrators have pointed to the ETEAMS program as being responsible for increases in science (and mathematics) scores. One elementary school saw a 20% improvement in science proficiency in Grade 5.

Qualitative Remarks from ETEAMS Fellows

Focus groups comprised of ETEAMS fellows revealed the following quotes regarding the ETEAMS program. Remarks concerning self efficacy:

> "Because I was so not science, no way. Can't do that....Then I think being in <ETEAMS>...it was like, 'Oh, this is really fun. The kids love it, I love it, these (lessons) are super interactive."

Remarks on building professional relationships:

> "...it was a great collaboration among people from <ETEAMS> and teachers. Because I don't think the other regular student teachers had any kind of collaboration on any types of anything. And they need to."

Remarks concerning Grades 4-8 students' attitude and interest in STEM:

> "It's fun and it's interactive, and the kids love it. Middle schools kids love it."
> "I mean, we get the positive feedback from the children themselves. They're always asking, 'When are you coming back? When are you coming back?"

Regarding modeling of best practices:

> "You know, I used to think–I came into this program thinking that I was going to do math–I know how to do this problem, I show the kids how to do this problem and they'll understand it, too. But there's a whole other level of math and science to teach. And you have a whole other standard to how your kids so that they can reach."

When focus group subjects were asked to describe their experience with ETEAMS in one word, the following were provided: hands-on lessons, leadership, engaging, exciting. Other focus group data is very encouraging in describing the positive ways that ETEAMS fellows were impacted by the experiences provided.

Initial Assessment: Lessons Learned

Initial findings show that PSTs benefitted from having site based experts available to support them as they merged theory with practice in developing and implementing research-based mathematics and science lessons. The ETEAMS investigators and TAMUCC faculty need to expand the PD model to engage PSTs in longer instructional units that integrate understandings of the NOS and mathematical concepts as they experience the essential elements of these disciplines including: building theories and models, collecting and analyzing data, constructing arguments and using specialized ways of talking, writing and representing ideas (Duschl & Grandy, 2012). The ETEAMS initiative would be strengthened by increasing the number of recent graduates of the program that serve as mentors to current PSTs as well as training Cooperating Teachers within the schools. This would lead to a transformation of the way that 4^{th}-8^{th} grade students, their teachers, and the PSTs are able to enhance and deepen their mathematical and scientific knowledge.

Implications

Policy support does matter, but in order to know what kind of support will most serve comprehensive PD, one must first understand the school context. A customized approach could result in differential emphases on various dimensions of capacity, depending on local needs at given points in a school's development. In this study, ETEAMS PD helped to strengthen a collaborative work culture and increase capacity building by first, having principals committed to whole school development for math and science. Math and science faculty were involved in working together on common goals and programs, structuring teachers' work around collaborative planning in grade level teams. Principals arranged for common team planning time and gave high priority to school wide and grade level PD. In addition, the ETEAMS PD program itself promoted team collaboration that included the school and TAMUCC faculty. During implementation, TAMUCC faculty and teacher leaders sought and discussed teacher feedback about the program – how to cope with difficulties, possible suggestions for program revisions, and orientation to forthcoming changes. Inservice teachers had a great deal of input and influence on lesson planning and content. TAMUCC faculty provided ideas and input, and recommendations and concerns were discussed in meetings with the principals.

Admittedly, the task ahead of PD facilitators and teacher educators is a challenging one, especially given the expectations of NGSS (Achieve, 2013) and the National Council of Teachers of Mathematics (NCTM, 2014). While it may be tempting to try and focus on only knowledge or beliefs, research indicates that attempting to impact both results in greater change (Loucks-Horsley et al., 2010; Lumpe, Szerniak & Haney 2012). This change does not happen quickly and therefore, pre- and inservice teachers should be provided with extended experiences, frequent feedback and a strong, supportive professional learning community reinforced with structured mentoring to increase both knowledge and efficacy in STEM instruction.

As educators and researchers, we constantly reflect on our practice for personal and professional growth. By engaging in ongoing evaluation of professional development and teacher training, we learned as a team to help preservice and inservice teachers focus on the process of science and mathematics by integrating meaningful instruction, reflection, feedback and authentic practice in our PD model. We were able to support preservice teachers' growing knowledge of science and mathematics teaching and instruction to best benefit student learning. Results show that implementation of the ETEAMS program helped to better equip preservice and inservice teachers to prepare science and mathematics students in the ever changing world of our global society. SUP

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