Vision, Goals, and Outcomes

Elementary Teachers Engaged in Authentic Math and Science (ETEAMS) is a transformative partnership that builds on a rich history of collaboration and shared commitment to STEM excellence among Texas A&M University – Corpus Christi (TAMUCC) and Corpus Christi Independent School District (CCISD). The partners propose establishment of a new field-based teacher education program that supports preservice elementary teachers' transitions to high-demand positions in middle levels STEM teaching. This new fellowship program leverages resources of the largest school district and largest university in the Coastal Bend region of Texas to test a scalable model for improving grades 4-8 STEM teaching and learning.

> *Our **guiding purpose** is to support an inclusive culture of STEM success and "hard fun" among grades 4-8 students and teachers in economically disadvantaged urban schools.*

The ETEAMS program design is grounded in local and national needs for middle levels STEM teachers, broad-based experience of project leaders, and an understanding of students and teachers in our community. The central feature of our program is a preservice teaching fellowship program to support generalist elementary education majors' participation in experiences that build their STEM awareness, content knowledge, self-efficacy, and interest in teaching middle levels mathematics and science.

> *Our **vision** is of an inclusive community in which preservice elementary teachers build the knowledge, experience, beliefs, and dispositions needed to challenge and support underrepresented young adolescents to achieve excellence in STEM learning.*

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.
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.

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 contributions to STEM teaching and learning and K-8 teacher preparation literature.

Key Feature: Partner Driven

Corpus Christi, TX, with a population (307,953 in 2011) about that of Pittsburgh, is a diverse industrial city with two military installations, the 5th largest U.S. port, and large economic activity in health services and oil development. Located on the Gulf of Mexico, Corpus Christi is the second largest city (behind San Antonio) in the fast growing and predominantly Hispanic region known as South Texas. Together with Del Mar Junior College, core partners Texas A&M University – Corpus Christi (TAMUCC) and Corpus Christi Independent School District (CCISD) are the three largest educational organizations in the city by a wide margin.

CCISD serves over 38,000 students at 60 campuses, including 38 elementary schools, 12 middle levels and 5 high schools structured as 5 vertical learning communities with coordinated curricula. Teacher to student ratios are approximately 25 to 1. Three relevant official district priorities include (1) ensuring academic progress for all students, (2) ensuring students graduate prepared for success in post-secondary education, and (3) developing a culture of “innovation with evidence” resulting in high quality academic choices for students and families. CCISD has a strategic partnership with TAMUCC for staff development; administrators report critical needs for highly qualified middle levels and secondary STEM teacher candidates and ongoing needs for quality professional development for teachers on issues affecting STEM education.

TAMUCC is part of the Texas A&M University System, a network of nine universities, seven state agencies and a comprehensive health science center. Federally designated as a Hispanic-Serving Institution with an annual budget of $158 million, TAMUCC is a 4-year university with an enrollment of more than 10,500 students (95% from Texas, 48% from Corpus Christi) located on a 240-acre island just southeast of downtown Corpus Christi. More than 70% of students receive financial assistance, 75% work full or part-time, and 63% graduate in 6 years or less. The university also houses the Harte Research Institute for Gulf of Mexico Studies, a $46 million endowed center for Gulf Coast research and policy. TAMUCC offers bachelor's programs in engineering as well as active STEM master's programs in mathematics, education, environmental sciences, and doctoral programs in marine biology, coastal and marine system science, educational leadership, and curriculum and instruction.

Our inspiration for developing the ETEAMS program is the success of an 8 year collaboration for science instruction at one of the partnering schools. During 2004-2011, Denise Hill (co-PI) led preservice teacher field experiences at Schanen Estates Elementary, working closely with principal Pamela Wright (co-PI). When a new TAKS grade 5 science exam was implemented, students and teachers needed more hands-on experiences in science. With Dr. Hill's guidance, grades 3-5 teachers learned to implement integrated science and mathematics instruction while preservice elementary teachers took on important roles for leading lab-based science experiences twice per week. Research (Hill & Bolick, 2008) found classroom teachers benefited from the collaborations and students showed marked improvements on science content. Grade 5 students outperformed nearly all other elementary schools in CCISD on the state science assessment, with minority students demonstrating the largest achievement gains.

Key Feature: Teacher Quality, Quantity and Diversity

CCISD employs over 1,800 (FTE) teachers, and 47% of new hires are TAMUCC graduates (CREATE, 2009). However, TAMUCC typically graduates only about 15 middle levels mathematics and science specialists annually, and those graduates filled just 9 of 50 new hires in grades 4-8 mathematics and science last year. With improving economic conditions and increased enrollment, principals report increasing hiring needs and "little to no selection of qualified candidates" for teaching vacancies in mathematics and science content. As a result,

many new middle levels mathematics and science teachers in CCISD have alternatively certified secondary specialists or elementary generalists.

At TAMUCC, more than 200 students earn generalist elementary education degrees annually, 14% of degree completers and more than 10 times the number of grades 4-8 mathematics or science education degree earners. By preparing a substantial proportion of elementary education majors for middle levels STEM teaching, ETEAMS will have a large effect on the quality, quantity, and diversity of the local teacher education workforce.

Quality. The proposed fellowship project improves the quality of grades 4-8 STEM instruction by (1) deepening preservice elementary teachers' content knowledge in middle levels science and mathematics, (2) establishing institutional supports for evidence-based practices in STEM education such as vertically aligned instruction across school campuses, peer-assisted STEM instruction, and integrated STEM curriculum, and (3) engaging preservice teachers, classroom teachers, and grades 4-8 students in authentic STEM research processes.

Quantity. We increase quantity of grades 4-8 STEM teachers both by supporting more initial certifications of middle levels mathematics and science teachers and by setting up supports 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. Similar to large districts in San Antonio, Dallas, and Houston, CCISD is a large school district in which the **majority of both students and teachers are of underrepresented ethnicities in STEM professions**. CCISD *students* are 77% Hispanic, 15% White, 5% African American; CCISD *teachers* are 52% Hispanic, 44% White, 3% African American; TAMUCC students are 43% Hispanic, 42% White, 5% African American, 5% International. Through recruiting and responsive program design, we estimate a total of over 70 Hispanic fellows will graduate the ETEAMS program prepared for middle levels STEM teaching careers.

Key Feature: Challenging Courses and Curriculum

ETEAMS coordinates a selective, cohort-based middle levels STEM teaching fellowship program for preservice elementary teachers. Fellows will be 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.

Goals for ETEAMS Fellows

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

Beginning in summer, and continuing into the academic year, fellows will collaborate with inservice teachers, mathematicians, scientists, and science graduate students on **original scientific research projects** featuring seven Gulf Coast ecological phenomena, including the

depositional history of tidal flats, organic matter input into Nueces Bay, composition of seagrasses in South Texas, seasonal variation in seagrass composition, Laguna Madre seagrass habitat, shell variation of beach clams, and flatworm behavior. Research teams will synthesize research results and related classroom activities through a new educational website, **ETEAMScc.com**. Then, cohorts will complete extensive **field-based preparation** for grades 4-8 STEM teaching by participating in an augmented *professional development school* partnership. Preparation includes classroom observations, guided practice in classroom teaching, grades 4-8 supervised student teaching, a weekly STEM Teaching workshop with teacher-leaders and university faculty, development of web-based STEM instruction materials, and facilitation of small groups of grades 7 or 8 students in leading peer-assisted mathematics or science instruction with grades 4 or 5 students. Finally, participants will complete one of two **certification exam workshops** taught by STEM education faculty on the pedagogical content knowledge required for earning grades 4-8 mathematics and science certification.

Key Feature: Evidence-based Design and Outcomes

The ETEAMS program is an ambitious, multi-level partnership spanning a number of interconnected systems, including an interdisciplinary preservice teacher preparation program, three interconnected schools serving grades 4-8 students, and university faculty from at least two colleges and four departments, and a predominately Hispanic urban community. The complexity of the collective educational system far exceeds the sum of its observable individual parts. While recognizing complex educational processes, the research program contributes to STEM education literature through methodologically **rigorous qualitative inquiry** surrounding social cognitive aspects of fellowship participants' experiences and advanced statistical modeling of comparative data through a **longitudinal matched group quasi-experimental design**. Moreover, the ethnic diversity of participating students and teachers, combined with the scale of implementation, raises the statistical power and practical significance of research linking the fellowship program to STEM teaching and learning outcomes among participants.

Key Feature: Institutional Change and Sustainability

Though establishing a national model for STEM teacher preparation is an major undertaking, ETEAMS leadership is even more concerned with supporting real and lasting improvements to the K-16 STEM education system in our community. ETEAMS will lead a numerous new processes at TAMUCC, resulting in increased involvement of STEM faculty and graduate students with preservice teachers, increased capacity for grades 4-8 education research and instructional coaching by STEM education faculty and staff, and refined approaches to field-placement and advising of preservice elementary teachers. At CCISD, the partnership directly supports expanding the implementation of vertically aligned STEM curriculum and evidence-based STEM instructional strategies, improved capacity for peer-assisted instruction and participatory laboratory activities in grades 4-8, and new strategies for recruitment, retention, and professional development of grades 4-8 mathematics and science teachers. The core partners are committed to continuing school partnerships well-after the funding period and will seek potential funding for continuing the fellowship program and associated professional development partnerships through both formal and informal routes.

Research and Implementation Framework

Rationale: Why Prepare Preservice Elementary Majors for Middle levels STEM Teaching?

For many students, grades 4-8 are marked by difficult developmental and educational transitions (Jackson & Davis, 2000; McEwin et al., 2005). In mathematics and science

classrooms, especially in low income and high minority schools, these transitions are complicated by shortages of teachers who are well prepared and supported to effectively foster success and interest in science, technology, engineering, and mathematics among young adolescents (Boyd et al., 2011; Stronge, 2007). Fewer than half of middle school teachers have completed the minimum number of recommended science courses (Fulp, 2002) and many hold significant misconceptions about science (e.g., Kruger, Summers, & Palacio, 1990).

One source of middle levels mathematics and science teachers are elementary generalist teachers. Almost half of middle levels mathematics teachers have elementary generalist certification, and about 25% have previously taught in grades K-4 (Hill, 2007). The commonly traveled pathway from generalist elementary teacher certification to a middle levels mathematics or science specialists is reinforced by a combination of *high teacher turnover* – almost 17% of middle levels science teachers leave their school and 27% switch subjects annually (Roby, 2002), *state teaching certification policies* – just 3 states require middle levels teachers to have a major in the subject they teach while 42 states offer exams to add middle levels subject certification (NRC, 2010), and *large numbers of elementary teachers* – generalist undergraduate and graduate elementary education degrees are among the most completed in the U.S. (NRC, 2010; NCES, 2012). Many of these new STEM teachers have very limited preparation for effectively teaching adolescents about mathematics or science, often just 1-3 content courses in a generalist education program (CMBS, 2012) augmented by self-directed preparation for a content-focused middle levels certification exam.

Many teacher education programs offer graduate programs for inservice teachers making the transition to middle levels mathematics or science teaching. Though they may be professionally worthwhile, inservice transitions *worsen* problems of high turnover among teachers that in turn dampens reform efforts and costs schools over $2 billion annually (Alliance for Excellent Education, 2005). **ETEAMS establishes an unconventional and innovative *preservice* strategy for bolstering the elementary to middle levels STEM teaching pathway**. The proposed fellowships provides empirical evidence on early career fellowships aimed at increasing the preservice elementary-to-middle-school-STEM pathway by offering (a) preservice elementary teachers chances to improve their employability and add middle levels STEM credentials without switching majors or delaying graduation, (b) universities an evidence-based new model for middle levels teacher preparation, and (c) local students and schools the benefits of new instructional collaborations and improved quantity, quality, and diversity of teachers.

Theoretical Framework

The conceptual framework supporting the ETEAMS program design comes from teacher education literature and the social cognitive perspective on human learning (Bandura, 1997). Social cognitive theory views learners as *agents* who actively work to shape their destiny based on *outcome expectancies* (i.e., perceptions of what will happen) and ***self-efficacy***, which refers to beliefs regarding one's ability to perform a specific task under specific conditions. In modeling of academic performance, self-efficacy is one of only a few variables that have ever been identified as a better statistical predictor of performance than *prior performance* and *ability* (e.g., Bandura & Locke, 2003). Recent research suggests ***calibration*** (the accuracy of self-efficacy beliefs) has important mediating effects on the relationship between self-efficacy and performance in middle levels, especially in mathematics (Chen & Zimmerman, 2007).

Self-efficacy is important for STEM teacher preparation because it influences the *decisions* individuals make, the *goals* they set, the *effort* they are willing to exert on reaching those goals, and the ***persistence*** they display when faced with obstacles (Pajares, 2005). Students with high self-efficacy in science and mathematics are more likely to set challenging goals and work harder to accomplish those goals, and are more likely to express ***interest*** in STEM-related

professions (Eccles, 1994; Lent, Brown, & Hackett, 1994). It is important to note that mechanisms of self-efficacy development are highly connected to contextual and cultural factors, such as ethnicity (Pajares & Kranzler, 1995) and gender beliefs. For example, high self-efficacy has a stronger predictive role in the vocational choices of girls than those of boys (Larose, Ratelle, Guay, Senécal, & Harvey, 2006).

Despite thousands of studies on self-efficacy in educational contexts (Lightsey, 1999), research on interventions to improve self-efficacy in middle levels STEM teaching or learning are exceedingly rare (Beier & Rittmayer, 2008). STEM education research (e.g., Zeldin, 2000) has, however, supported Bandura's (1997) claims that **four sources of self-efficacy** beliefs, including *mastery experience* (related prior experience and performance), *vicarious experience* (observations of others performing similar tasks), *social persuasion* (feedback from others on performance and ability), and *physiological reaction* (emotional and physical states). In their review of research on the sources of self-efficacy in school settings, Usher and Pajares (2008) specifically recommended research on interventions aimed at increasing mathematics and science self-efficacy in middle levels schools. In this vain, ETEAMS enacts a theoretically-grounded approach to increasing STEM outcomes through mediating effects of self-efficacy.

Theory of Action

The ETEAMS program design flows from the following hypothesized implementation claims:

1. Project leadership will successfully recruit and select annual cohorts of Senior preservice elementary education majors for a middle levels STEM teaching fellowship.
2. Preservice teachers joining the fellowship program will be likely to complete an elementary education degree during the project period, and some will continue in the fellowship as peer-mentors while they begin a middle levels STEM teaching career.
3. Fellows and teachers will contribute to authentic STEM research experiences, and the experiences will have positive impacts on their STEM interest, views on the nature of science, and self-efficacy in STEM domains.
4. Fellows will engage in enriching middle levels STEM teaching activities, and those activities will increase their interest and self-efficacy in middle levels STEM teaching
5. Fellows will complete a grades 4-8 mathematics or science content preparation workshop. Most will complete and pass the related certification exam.
6. Collaborations between fellows, inservice teachers, and STEM education faculty on teacher-led grades 4-8 instructional reform will be mutually beneficial and productive; fellows and teachers will have improved views on the nature of science, self-efficacy in STEM domains, and STEM interests.
7. Fellowship-coordinated participation of fellows, STEM experiences, and STEM teaching reforms will lead to improved STEM instruction for Grades 4-8 students.
8. Grades 4-8 students who experience improved STEM instruction will demonstrate improved STEM interest, STEM self-efficacy, beliefs about the nature of science and mathematics, and STEM achievement.
9. Graduates of the fellowship program will contribute to improved quality, quantity, and diversity of the South Texas middle levels STEM teaching workforce.
10. Ongoing research, program development, and evaluation cycles will contribute to K-8 teacher education and STEM education literature.

Model for Field Based Teacher Preparation

The classroom-based features of the fellowship program draws heavily from a teacher education partnership between TAMUCC and CCISD. In place since 1990, the Educator Preparation Program (EPP) partnership has institutionalized structures supporting the critically important clinical field experiences of thousands of preservice teachers in high-poverty urban schools. Through EPP partnerships, preservice teachers experience complete content-based science and mathematics foundations courses in Numbers and Operations, Probability and Statistics, Geometry & Measurement, Life Sciences, Physical Sciences, followed by three field-based semesters of coursework at CCISD partner schools, which in turn offer classroom space for education courses and professional development. The first field based semester includes **classroom observations** as part of twice-weekly course meetings at a partner school, a second semester adds **guided practice in classroom teaching** during course meetings, and a final semester includes a 13 week **supervised student teaching** apprenticeship.

EPP partnerships follow a *professional development school* model for offering preservice education courses (Hill & Bolick, 2008) . Benefits include regular presence of TAMUCC clinical faculty at the field site and explicit opportunities for classroom teachers to both mentor and collaborate with preservice teachers. By spending two days per week at schools for three semesters, preservice teachers often develop positive relationships with the stakeholders of the school community and participate in academic and non-academic activities with students, teachers, parents, administrators, and clinical professors. From the perspective of CCISD partner schools and TAMUCC faculty, intentional ongoing professional development opportunities play a vital role in growing and sustaining EPP partnerships in local schools. Professional development activities have ranged from informal collaborations with preservice teachers to interactive small-group inquiry of STEM content, faculty workshops on STEM education issues, and expert support for integrated mathematics and science instruction.

Implementation of the Fellowship Program

Recruitment of Fellowship Participants

In late Spring, annual recruitment and selection of ETEAMS cohorts will take place in parallel with generalist elementary education majors' field placement process. Materials will be shared with all Senior elementary education majors (approximately 300 annually), and those with demonstrated success and interest in STEM content will be invited to apply. Indicators of such success could include completing at least 3 of the required 5 mathematics and science content courses with a grade of B or better, completing advanced mathematics or science courses outside the major, or a reference from a teacher or faculty member. All applicants will submit an essay on their interest in adding middle levels teaching certification and prior success in mathematics and science subjects. Led by co-PI Denise Hill, project leadership will use institutional records on applicants, including Texas Higher Education Assessment (THEA) mathematics scores, grades in STEM courses, and recommendations of STEM education faculty to select cohort participants. Based on recent years, approximately 150 Senior elementary education majors will be eligible to apply for ETEAMS, and **3 annual cohorts of 40 fellows** will prepare for middle levels STEM teaching through activities centered on 4 goals:

Fellowship Goal #1: Participate in Authentic STEM Research

ETEAMS leadership sees mutual benefits of engaging scientists and mathematicians with preservice elementary teachers, and fellowships feature 30 hour summer STEM research experiences in which preservice elementary teachers contribute to **original scientific research projects**. Fellows will work with masters' and doctoral science students, mathematicians and

science faculty to collect and analyze data for modeling seven Gulf Coast ecological phenomena, including the depositional history of tidal flats, organic matter input into Nueces Bay, composition of seagrasses in South Texas, seasonal variation in seagrass composition, Laguna Madre seagrass habitat, shell variation of beach clams, and flatworm behavior.

1. Depositional History of Tidal Flat Regions – Sediments in marine and fresh water settings record the depositional history of the water body. Since tidal flats fluctuate between dry and submersed conditions, chemical analysis can indicate climate and environmental impacts such as droughts, wet periods, fires, and pollution events.
2. Organic Matter Input into Nueces Bay – One of the pathways of introducing terrestrial organic matter to lakes and oceans is through river transport, and the nature of the organic matter depends on the type of vegetation. Sediment cores at sites along the Nueces River allow the investigation of variations in organic matter input of Nueces Bay.
3. Composition of Seagrasses in South Texas – Carbon/nitrogen ratios (C/N) of plants are a reflection of their chemical composition. Seagrasses of the species *Halodule Wrightii* will be collected from various locations in bays of South Texas, and observed differences in C/N ratios will be used to investigate variations in environmental settings between the bays.
4. Seasonal Variation in Seagrass Composition – Seasonal changes in carbohydrate and amino acid concentrations as well as C/N ratios in various seagrasses have been documented. This study is designed to investigate changes in n-alkane and fatty acid compositions in *Halodule Wrightii* associated with seasonal temperature change.
5. Laguna Madre Seagrass Habitat – The Laguna Madre, a unique hypersaline Lagoon in Texas, contains more than 600 km^2 of seagrass habitat. During 3 days and 2 nights at a field station, participants will learn techniques for sampling seagrass bed organisms and how relative abundance of organisms is influenced by abiotic conditions
6. Natural Variation of Beach Clams – Beach clams, Donax sp., and ubiquitous on the Texas Gulf Coast. Their color patterns are highly variable. Participants will collect beach clams from areas frequented by people and areas that are less accessible. We will compare frequency of each color pattern in juvenile vs. adult clams to ascertain how the color pattern changes through time and how natural selection modifies variation.
7. Flatworm Behavior – Planarians are flatworms in the phylum Platyhelminthes. They are bilaterally symmetrical and have an eyespot on their anterior end which is sensitive to light and sense organs that detect chemicals and touch. Participants will study how various stimuli affect planarian behavior, specifically four types of taxis.

Research experiences naturally lead to new questions, new experiments, and, especially when teachers and teacher educators are part of the conversation, new ideas for the classroom. In anticipation of this, summer STEM research experiences will continue throughout the academic year and, led by co-PI Champion, research teams will synthesize research results and related classroom activities through a new educational website, **ETEAMScc.com**. Participating inservice teacher-leaders will join the STEM research working groups during the academic year, focusing on connections to the classroom and how the research experiences have impacted participants' views on the nature of science, engineering, mathematics and technology.

Fellowship Goal #2: Engage in Middle Levels STEM Teaching

Fully developed EPP professional development school partnerships are already in place at six elementary schools, two middle levels, and one high school, including the three ETEAMS school sites: **Kostoryz Elementary**, **Schanen Estates Elementary**, and **Tom Browne Middle**. ETEAMS extends existing EPP partnerships at the three partner schools by (a) supporting a

cadre of preservice elementary teachers to focus on middle level STEM teaching and learning, (b) adding involvement of scientists and mathematicians and authentic STEM research activities, and (c) offering active roles for graduating fellows during the first two years of classroom teaching.

In addition, to support partnership goals, administrators at the three ETEAMS school sites will arrange for **common planning times across campuses** for participating classroom teachers to collaborate with fellow teachers in other disciplines, grades, and campuses. Led by co-PI Denise Hill, and supported by all key personnel, the common planning will occur as part of **Science Thursdays**, a weekly 2-hour outreach and instruction effort in which TAMUCC faculty and graduate students will engage all participating grades 4-8 students in authentic mathematics and science experiences (e.g., demonstrations on current research projects), while fellows and teacher-leaders participate in a coordinated STEM Teaching workshop.

Fellowship Goal #3: Middle Levels Mathematics and Science Certification

During the semester prior to undergraduate graduation, ETEAMS fellows will participate in one of two **workshops for passing grades 4-8 mathematics and science certification exams**. The curriculum for the workshops was developed and pilot tested in Spring 2012 as part of the*Teacher Recruitment Initiative for High Needs Areas* grant-funded program for preparing inservice local teachers for secondary STEM instruction. In the initial implementation, 25 of 36 (69%) of participants completed and passed the grades 4-8 TExES mathematics or science certification exam. Facilitated by co-PIs Champion and McCollough, workshops feature biweekly Saturday content instruction, content-focused study materials, and standards-based practice on middle levels mathematics and science content. Starting in Year 2, instructors of the certification workshops will recruit fellows who had previously completed middle levels STEM certification as mentors for the new cohort of participants.

Fellowship Goal #4: Collaborate with Inservice Teachers

To support partnership goals for excellence in STEM teaching, administrators at the three ETEAMS school sites will arrange for **common planning times across partner campuses** for participating classroom teachers to collaborate with fellow teachers in other disciplines, grade levels, and campuses. Initial plans are for ETEAMS to lead weekly two-hour STEM experiences for students at the partner campuses on **Science Thursdays**. Led by co-PI Denise Hill, these weekly collaborative workshops will include a 3-week rotating schedule of featured presentations on (a) emerging findings from the STEM research projects, (b) evidence-based STEM instructional strategies, and (c) selections of "best of the best" instructional efforts among participating teachers.

Led by Kim Moore, an instructional coach employed by the TAMUCC Department of Mathematics and Statistics, preservice teachers, classroom teachers, and school administrators will collaborate on teacher-led **evidence-based mathematics and science instructional reform** at the partnering schools. Reforms will be planned to complement CCISD's curriculum coordination at the vertical learning community level and will be responsive to emerging instructional needs and district-led scope and sequence planning of curriculum planning. Initial plans are to explore the use of integrated STEM curriculum across campuses, increased use of coordinated science experiments in grades 4 and 5, vertical alignment of terminology across grades 4-8 STEM disciplines, and peer-assisted instruction projects in which small groups of grades 7 and 8 students lead mathematics and science activities for grades 4 and 5 students. Preservice teachers will facilitate the teacher-led reform efforts, posting the "best of the best" results from classroom efforts to ETEAMScc.com, and leading peer-assisted instruction.

Research Questions

As a prototype partnership project, ETEAMS is a research and development effort designed to generate rigorous data-based findings of national significance. In addition to formative internal evaluation of ongoing program data and an external evaluation program of program outcomes, the project leadership is committed to a robust research program. The mixed methods research design focuses on two quantitative (Q1 & Q2) and two qualitative (Q3 & Q4) questions informed by the theoretical framework surrounding the social cognitive approach to teacher education.

Q1. To what extent does participation in the ETEAMS middle levels STEM teaching fellowship program influence the:

a. ***views on the nature of science*** among preservice elementary teachers, university faculty, and grades 4-8 students and teachers?

b. ***self-efficacy in grades 4-8 STEM content*** among preservice elementary teachers, classroom teachers, and grades 4-8 students?

c. ***STEM interest*** among preservice elementary teachers, and grades 4-8 students and teachers?

d. ***mathematics and science performance*** among preservice elementary teachers and grades 4-8 students?

Q2. To what extent does participation in the ETEAMS middle levels STEM teaching fellowship program influence the:

a. quantity, quality, and diversity of new ***grades 4-8 mathematics and science certifications*** earned by teacher education graduates?

b. quantity, quality, and diversity of ***new grades 4-8 STEM teacher applications and hirings*** for nearby school districts?

c. **professional trajectory, persistence, and mobility** of generalist elementary education graduates?

Q3. What mechanisms, resources, and policies **support and constrain effective implementation** of a middle levels STEM teacher fellowship program for preservice elementary teachers?

Q4. In what ways do preservice elementary teachers in a middle levels STEM teacher fellowship program use and interpret **sources of self-efficacy** and reflect on their **beliefs about inclusiveness, teaching, learning, science, and mathematics** throughout their participation in the fellowship?

Research Design

The ETEAMS program is an ambitious, multi-level partnership spanning a number of interconnected systems, including an interdisciplinary preservice teacher preparation program, three interconnected schools serving grades 4-8 students, and university faculty from at least two colleges and four departments, and a predominately Hispanic urban community. The complexity of the collective educational system far exceeds the sum of its observable individual parts. Characterizing direct effects of the partnership on STEM teaching and learning is necessarily complicated by many intervening variables, including local, state, and national policy, economic conditions, and direct and indirect mechanisms supporting and constraining program implementation. Cognizant of this complexity, the research program presents great opportunities for both richly descriptive longitudinal qualitative research and advanced statistical modeling of matched group comparative data. Moreover, the ethnic diversity of participating

students and teachers, combined with the scale of implementation, raises the statistical power and practical significance of research linking the fellowship program to STEM teaching and learning outcomes among participants.

Led by co-PI Cherie McCollough, the robust quasi-experimental *quantitative* strand of the research addresses Q1 and Q2 by statistically controlling for intervening variables through a **longitudinal matched group design** in which participant outcomes are statistically compared to corresponding outcomes among teachers and students at schools with similar educational and demographic profiles. Led by co-PI Joe Champion and key-personnel Matt Bowers, the qualitative inquiry component of the research design is essential for painting a more nuanced portrait of the program and for filling in the 'space between the lines' of quantitative findings and evaluation of program outcomes. The qualitative research team will address Q3 and Q4 using focus group interviews, immersive ethnographic field study of the experiences and activities of fellows, and semi-structured interviews. Findings will include rigorously grounded evidence to explain *why* and *how* the program functions as it does – particularly with respect to explicating the individual, intragroup, and intergroup experiences of stakeholders.

Data Sources and Instrumentation

Much of the research data sources use instruments and protocols from recent research among project leadership, and the research design employs several existing instruments with published analyses of delimitations, reliability, and validity. Teachers' self-efficacy in mathematics and science will be 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 will be 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 will be measured by the VNOS-C survey (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002).

Implementation of mathematics and science instructional practices will be assessed using composite scores from classroom observations by ETEAMS staff and self-reports on the well-developed and widely-implemented 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 NSF). Data on the quality, quantity, and diversity of middle levels STEM teaching workforce in Corpus Christi and surrounding areas will come 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).

Evaluation Plan

The Education Research Center (ERC) at Texas A&M University (TAMU) will be responsible for the external evaluation activities for the ETEAMS Partnership project. ERC researchers are involved in a number of research and school-based evaluation projects, and the evaluation of the ETEAMS Partnership project fits into the mission of the ERC in that the project is designed to enhance STEM teacher preparation and professional practice—and ultimately students' academic achievement. Drs. **Jacqueline Stillisano**, ERC co-director; **Hersh Waxman**, professor and ERC director; and **Danielle Brown**, ERC coordinator of STEM research, will serve as co-PIs and lead the evaluation efforts on this project. Their research skills are complementary: Stillisano specializes in qualitative methods such as in-depth interviews, Brown

specializes in quantitative data analyses, and Waxman specializes in mixed methods research. The three of them collectively have a wealth of experience in program evaluation of large, collaborative state and federally funded projects. Recent relevant evaluation projects directed by the evaluation team include *Evaluation of the Math, Science, & Technology Teacher Preparation Academies*, *Evaluation of the College Readiness Field Test Project*, and *Evaluation of the Math Texas Essential Knowledge and Skills (TEKS) Connections Project*.

The external evaluation team will use an evaluation methodology that examines both qualitative and quantitative dimensions of the project. It is based on a synthesis of the **Accountability, Effectiveness, Impact, Organizational Context,** and **Unanticipated Outcomes** (AEIOU) framework explicated by Sorenson and Sweeney (1997). The AEIOU framework will allow the evaluation team to examine whether project goals and related outcomes are met, as well as to investigate the processes and contexts that support the project's work and final products. Moreover, the results of the AEIOU approach provide both formative and summative information through an iterative process.

The *accountability* component of the evaluation will examine evidence that specific activities were implemented in a timely fashion. The *effectiveness* component looks past the actual completion of activities and attempts to assess how effectively project activities were implemented. The *impact* component will focus on results accruing from planned changes attributable to project activities, and the *organizational context* component will identify policies, structures, or events that facilitated or hindered the accomplishment of project goals. Finally, the *unanticipated outcomes* component will center on important, unexpected outcomes that can be attributed to the project.

The external evaluation team will document the development and implementation of the program across the 3 years of the project. The initial formative evaluation will verify the extent to which the program is implemented as planned. Reasons for possible implementation revisions will be reported, as well as the possible impact on project outcomes. The **formative evaluation** results will serve to identify implementation successes and failures and will be used to inform and strengthen program planning.

The external evaluation team will work with the project directors and staff to develop a summative report regarding the overall project that will be submitted to NSF. Outcome goals and related data sources are summarized in the following table. The overarching questions guiding the **summative evaluation** are as follows:

1. To what degree has the ETEAMS project achieved its goals, objectives, and outcomes?
2. What unanticipated outcomes have emerged as a result of the project?
3. What is transferable, replicable, and scalable as a result of the project; i.e., what can be adopted by other teacher preparation institutions in the state, other NSF projects, and the STEM teacher preparation field in general?

Outcome Goals	**Evaluation Data Sources**
1.a.1. At least three-fourths (90 total) of fellows complete the generalist elementary degree pass grades 4-8 science or math certification exam	State certification exam results
1a.2. At least two-thirds (78 total) of fellows work as Grades 4-8 STEM teachers in TX	Program records
1a.3. At least half (60 total) of fellows work in high-needs schools in TX	Program records
1.b.1. Increased math & science content knowledge among fellows	State certification exam results, pre-post tests
1.b.2. Increased evidence-based STEM instructional practices at participating schools	Classroom observations, teacher & principal surveys

Outcome Goals	Evaluation Data Sources
1.c.1. At least three-fifths (72 total) of fellows will identify in underrepresented groups	Program records
2.a.1. Increased number of hands-on STEM lab activities & inquiry-based investigations among Grades 4-8 students	Lesson plans, teacher & principal surveys
2.a.2. Increased Grades 4-8 student participation in STEM experiences led by mathematicians & scientists	Program records
2.a.3. Increased Grades 4-8 teacher participation in STEM experiences led by mathematicians & scientists	Program records
2.a.4. Increased student participation in science & math competitions	Program records
2.b.1, 2.c.1. Increased student, teacher, and fellowship participant interest and self-efficacy in STEM disciplines	Longitudinal survey data
2.b.2., 2.c.1. Increased student/preservice teacher interest and self-efficacy in STEM careers	Longitudinal survey data
2.d.1. Increased numbers of Grades 5 & 8 students achieving "proficient" status in science & mathematics	State science & mathematics assessments
2.d.2. Increased numbers of Grades 5 & 8 students achieving "advanced" or "recognized" status in science & mathematics	State science & mathematics assessments
2.d.3. Minimum of 90% of preservice teachers achieve normalized gains on released items from Grades 4-8 mathematics or science state certification exams	Pre-posttests, state science/mathematics certification exam results
2.d.4. Minimum of 50% of Grades 4-8 teachers achieve normalized gains on released items from Grades 4-8 mathematics or science state certification exams	Pre-posttests, state science/mathematics certification exam results
2.d.5. Consistent increases in STEM faculty ratings of fellowship participants' STEM research collaboration products	Program records
3.a.1. Cohesive framework for ETEAMS model developed	Program records
3.a.2. Template-based recruiting and informational materials developed and disseminated	Program records
3.a.3, 4.a.1, 4.b.1. Publications in refereed, math and science teacher education journals	Program records
3.a.4, 4.a.2 & 4.b.2. Presentations at state and national STEM teacher education conferences	Program records
3.b.1. Documentation of issues affecting ETEAMS scaling	Program records
3.b.2. Completed analysis of potential sites for scaling ETEAMS	Program records
3.c.1. Increased participation of STEM faculty and graduate students with preservice elementary teachers	Program records, survey data
3.c.2. Increased participation in middle levels mathematics and science education programs	Program records
3.c.3. Expanded implementation of vertically aligned math and science curriculum	lesson plans, teacher & principal surveys
3.c.4. Increased use of evidence-based science and mathematics instructional practices in Grades 4-8 classrooms	lesson plans, teacher & principal surveys
4.a.3 & 4.b.3. Policy brief on implications of program findings for middle levels STEM teaching and learning	Program records

Partnership Management / Governance Plan

The ETEAMS program was developed by a 9 person project leadership team who are eager to continue a long history of coordinated STEM education collaborations among the Colleges of Science and Engineering and Education at TAMUCC and CCISD. **Jim Silliman (PI)** is a geochemist in charge of the Leadership Team, **Joe Champion (co-PI)** is a mathematics educator leading the Program Development Team, **Cherie McCollough (co-PI)** is a science

educator leading the Research Team, **Denise Hill (co-PI)** is a middle levels teacher education and department chair of teacher education leading Implementation Team with **Pamela Wright (co-PI)** the principal at partner school Schanen Estates Elementary. Other senior personnel include ecologist **Lee Smee**, mathematician and department chair **George Tintera**, research consultant **Matt Bowers**, and secondary instructional coach **Kim Moore** (see details on individual contributions in the Supplemental Documentation).

Team Name	Major Responsibilities	Accountable Members (*Lead in Italics*)
Leadership	Planning and oversight	*Silliman*, Champion, McCollough, Hill, Wright
Implementation	STEM Research Projects, school partnerships, field experiences, content preparation workshops	*Hill*, Wright, Silliman, Smee, Tintera, McCollough, Moore, Wright, STEM faculty, science graduate students
Research	Data collection, analysis, publication, presentations	*McCollough,* Champion, Bowers, science graduate students
Program Development	Articulation, scaling, funding, website	*Champion*, Wright, Tintera, Champion

Institutional Change and Sustainability

Institutional Change at TAMUCC

ETEAMS leadership efforts will shepherd a number of identifiable changes at the higher education partner. Several of the most prominent include (1) improved involvement of STEM faculty and graduate students with preservice teachers, (2) increased participation of elementary education majors in content courses for specialized middle levels STEM education programs in the college of Science and Engineering, (3) refined approaches to field-placement and advising of preservice elementary teachers, (4) increased professional and research collaborations across the colleges of Education and Science and Engineering, and (5) improved capacity for grades 4-8 STEM outreach.

Institutional Change at CCISD

ETEAMS will support institutional changes at CCISD by addressing high-priority concerns for staffing, teaching practices, and achievement in grades 4-8 mathematics and science. Some of the key changes include (1) expanded implementation of vertically aligned mathematics and science curriculum, (2) increased use of evidence-based science and mathematics instructional practices among grades 4-8 teachers in partnering schools, (3) increased formal and informal use of integrated STEM curriculum, (4) improved capacity for peer-assisted instruction, (5) strengthened preservice teacher education partnerships, and (6) new strategies for recruitment, retention, and professional development of grades 4-8 mathematics and science teachers.

Sustainability

The tightly-knit partnership between CCISD and TAMUCC, woven by long-standing personal relationships, geographic proximity, economic supports, and shared educational vision, will only be strengthened by the ETEAMS partnership. Several elements of the partnership are expected to continue after the funding period, including the research program, educational website, content-based certification workshops, support of preservice elementary teachers for integrated

mathematics and science instruction and peer-assisted teaching in EPP school sites, and increased engagement of mathematicians and scientists with preservice teachers. The core partners are also committed to responding to outcomes of the ETEAMS fellowship program, and will actively seek internal and external funding sources for expanding the partnership.

Results from Prior NSF Support and Related STEM Education Grants

The proposed ETEAMS partnership is a natural next step for collaborations among the leadership team. Nearly every component of the proposed design builds on one or more efforts in projects led by key personnel during the past 10 years. One such project has been the **STEM Talent Expansion Program (STEP): Recruitment, Retention and Success in Science** (NSF DUE #0622530, $1,000,000, 2006-present, J. Giraldo, PI) initiative. STEP has specialized in *supporting Hispanic STEM students across achievement levels* (McCollough & Giraldo, 2009) by supporting a peer-mentoring program within freshman learning communities that include cohort-based biology, chemistry, and a mathematics courses (college algebra, pre-calculus, and calculus). Rates of students earning a C or better in mathematics and science classes has been 10 percentage points higher among STEP students, which has translated to large increases in retention of STEM majors. Jim Silliman (PI) and Cherie McCollough (co-PI) have helped lead implementation and research as co-PIs, and Matt Bowers (research consultant) served as an external evaluator. Moreover, the **Preservice Teachers Learning to Engage Hispanic Parents in Mathematics & Science** (NSF DUE #0536827, $121,000, 2006-2009, C. McCollough, PI), which included dozens of presentations and a still-thriving TAMUCC/CCISD partnership for evening family mathematics and science learning events led by preservice elementary teachers, and **The Cabeza de Vaca Earthmobile Program** (NSF GEO #0303139, $581,000, 2003-2007, J. Silliman, PI), which successfully developed and implemented geoscience lab activities for rural middle levels students in South Texas.

Other Related STEM Grants	Roles in Projects
1. *Teaching High School Students the Scientific Method through Involvement in an Ongoing Field Experiment* $93k, Texas Sea Grant (NOAA)	Lee Smee (PI) Cherie McCollough (co-PI)
2. *Teacher Recruitment Initiative for High Needs Areas* $95k, Sid W. Richardson Foundation	Joe Champion (key pers'l)
3. *Teacher Quality Program for Secondary Mathematics* $226k, Texas Higher Education Coordinating Board	Joe Champion (co-PI)
4. *South Texas Partnership for Algebra Transitions* $255k, Texas Education Agency	George Tintera (PI) Joe Champion (co-PI) Kim Moore (key pers'l)
5. *Mathematics and Science Teacher Academy* $478k, Texas Higher Education Coordinating Board	Denise Hill (PI) Pamela Wright (key pers'l)

Some key program components which are directly tied to our recent STEM grant projects include (a) evidence-based strategies for facilitating peer-assisted instruction, (b) curriculum materials for authentic STEM experiences in grades 4-8, (b) mechanisms for effective field placement of prospective middle levels STEM teachers, (c) university capacity for offering instructional coaching, (d) research-based school curriculum for integrated middle levels STEM learning, (e) mechanisms for implementing the professional development school model in teacher preparation, and (f) situated strategies for supporting middle levels STEM teachers.