Project Description: NSF INCLUDES DDLP: EMERGE in STEM (**E**ducation for **M**inorities to **E**ffectively **R**aise **G**raduation and **E**mployment **in STEM**)

1. Vision and Collective-Impact Statement

EMERGE in STEM is a Design and Development Launch Pilot that will (1) advance the knowledge and evidence base for successful collective-impact strategies, thereby broadening participation (BP) and inclusion of underrepresented minorities (URMs) in the STEM workforce; (2) strengthen diversity in STEM pathways with bold, innovative, collaborative, consistent, and persistent student exposure to exciting STEM career knowledge and opportunities, throughout the grade 4-12 continuum; and (3) build and demonstrate a collective-impact process/practice for national expansion to a BP collective-impact Alliance.

Pilot Long-term Goal: EMERGE in STEM envisions positively impacting women and at-risk minority populations in a high-poverty community in Guilford County, NC, where underrepresentation in STEM careers is influenced by complex equity, socioeconomic, and inclusion-related challenges. The targeted URMs in this project have unique challenges, including, in part: lower economic levels (63% poverty levels in Guilford County Schools); lack of effective parental advice, historical underrepresentation, low feelings of belonging, and low self-efficacy in STEM. Ultimately, our goal is to export our well-defined and documented processes/tools/resources to other URM-majority communities across the nation.

Broadening Participation Challenges Addressed: A diverse, well-prepared, and innovative workforce and STEM-literate citizenry are crucial to the Nation's health and economy (President's Council, 2012). The pipeline of URMs in STEM pathways is insufficient to address underrepresentation in both colleges and the STEM workforce (Hunt, 2015; NSF, 2015; Committee, 2014). In 2011, 26% of STEM workers were women, 9% were minorities (non-White, non-Asian) (NSF, 2011). Bold, large-scale, national initiatives from K-20 are needed (NSF, 2014). This Pilot begins to address the enduring national challenge, and the STEM divide (Hopewell, 2009), to increase the number of URM students on a competitive trajectory in the grade 4-12 STEM continuum (Arnold, 1993; Gloria, 1999; Luzzo, 1993).

Pilot Focus on Grades 4-12:

The crucial grades 4-12 were intentionally selected for this Pilot. There is strong evidence that by 4th grade, students begin to think about careers (Akos, 2007). UMass research suggests that 94% of middle school students make career-related decisions (UMASS, 2011). The National Research Council reports that for student interest in STEM to persist to workforce entry, it must be developed prior to leaving the 8th grade (National Research Council, 2011). By the time a student enters high school, thoughts of career are ever present. Finally, when a student graduates from high school, their decision to enter a STEM-oriented college program or job becomes intentional. The grade 4-12 scope of the Pilot addresses the population before entering college and the workforce.

One other key factor influenced the focus on grades 4-12. This Pilot will be studying both in-school and out-of-school STEM activities of many types. To assess the impact of career-exposure on students, an assessment instrument must be reliable, and validated across various types of STEM programs, and across the age groups represented. UMASS (2011) reported many issues when trying to evaluate multiple STEM programs in Massachusetts that all used different, non-validated tools for assessment. After review of research literature, two NSF funded possibilities emerged: Program in Education, Afterschool & Resiliency (PEAR) from Harvard University and McLean Hospital (Friedman, 2008); and Maximizing the Impact of STEM Outreach (MISO) (Friday Institute, 2012a and 2012b) from the Friday Institute for Educational Innovation at NC State University. Based on discussions with and publications from both PEAR (Hussar, 2008), and MISO (Unfried, 2015; Unfried, 2014), the MISO assessment instrument was selected for this Pilot. The validated MISO assessment instruments separately cover grades 4 & 5, and then grades 6-12. Since the Friday Institute is in Raleigh, NC, 75 miles from the PI's university in Greensboro, NC, opportunities for face-to-face collaborative discussions of MISO are enhanced.

Uniqueness and Innovation: This creative and transformative Pilot (1) embraces the collective-impact model (Kania, 2011); (2) brings together a local network that is replicable nationally (school district, colleges and universities, local commerce and industry, entrepreneurial ecosystem, community organizations, state department of education, and an educational-software-technology company); (3) expands the STEM collaboration to include extensive, network-partner members and their mutually reinforcing activities (MRAs, STEM activities and interventions); and (4) infuses career-exposure elements (CEEs) into MRAs to attract URM students into exciting STEM pathways leading them to the STEM workforce.

A review of all summaries for 2016 NSF INCLUDES awardees indicates that none had a significant focus on career-exposure impact for BP of URMs in STEM. This Pilot boldly/uniquely addresses that void.

Collective-Impact Strategic Plan: The Collective Impact Strategic Framework (the Framework) for EMERGE in STEM is shown in the 3-plane diagram (Figure 1; adapted from NSF Engineering Research Centers). Collective-impact success depends on fundamental STEM knowledge (bottom plane), employs enabling programs and technologies (middle plane), and requires a system-driven, grade 4-12 continuum effort (top plane).

The **bottom plane** represents the fundamental STEM learning that students receive in grades 4-12 primarily defined in the NC STEM Strategic Plan (North Carolina 2011-2020), aligned with state and national standards and objectives. Guilford County Schools (GCS) is primarily responsible for success on this plane for the Pilot. Key barriers to success are noted on the plane.

The **middle plane** represents individual MRAs (offered by community groups, universities, Chamber of Commerce, local employers, and others) that build upon the STEM Educational Knowledge Base. Mutual reinforcement of activities is *not assumed to exist* at the formation of the Network. In fact, there is no single website or listing for the multitude of STEM opportunities that Guilford County (GC) students may select from. To address this challenge, the Network of Partners will, for the first time in GC, fully catalog and link MRAs, and make them searchable on an EMERGEinSTEM.org website (mockup built from Wordpress shown later in Figure 5. Primary barriers are noted on the plane. Light green ovals in the middle and top plane represent opportunities for career-exposure infusion. For example, career exposure can be impactful from School/Career Counseling (Alston, 2000; Madill, 2004), Career Mentorships (Hill, 1990), Internships (Packard, 2003; Tisdal, 2005), Tutoring (Seymour, 1995), Parental Education (Malgwi, 2005), and others.

In addition to these STEM interventions, an extensive list of STEM-educational opportunities/organizations exist in GC, including in part: Science fairs; after-school enrichment clubs, science museums and learning centers; summer enrichment programs; competitions; career fairs; company presentations; varied work opportunities; conferences; and others. The Pilot will *make visible* the numerous MRAs to enhance BP for URMs across GC.

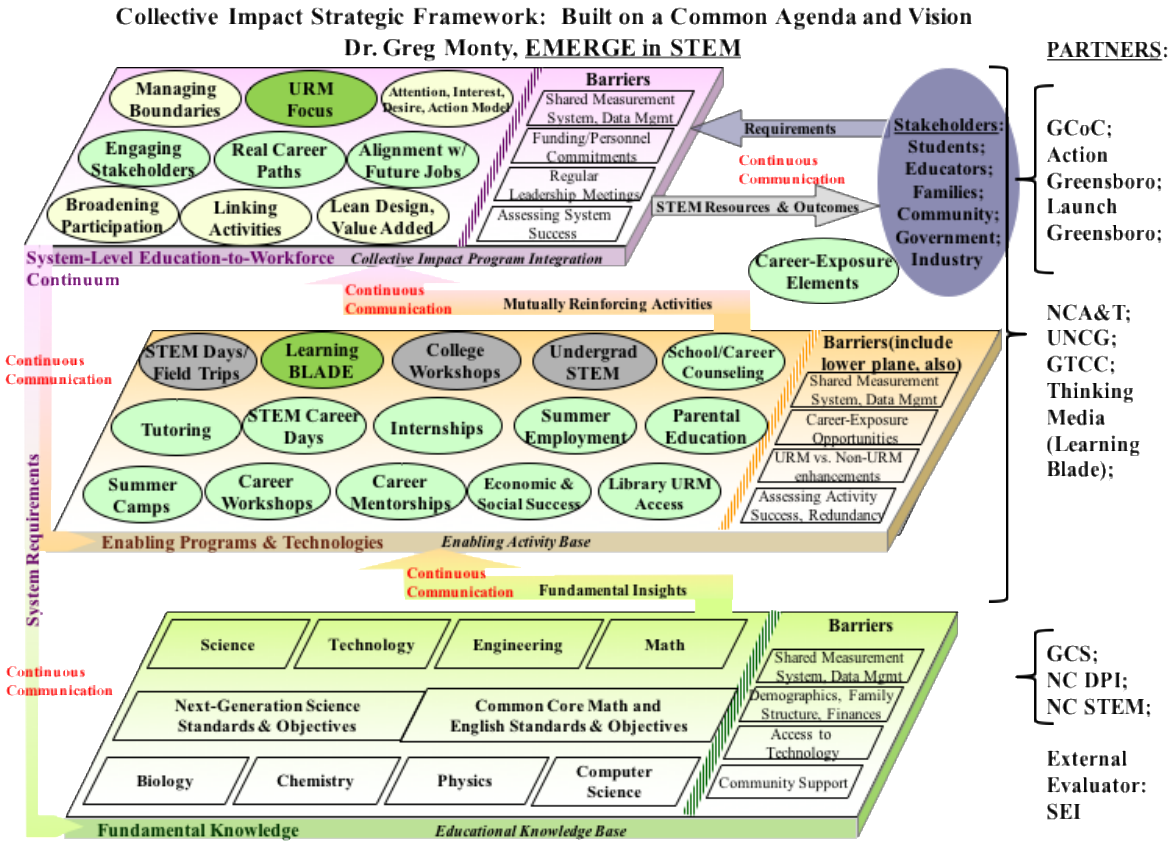

Figure 1. Pilot's "Collective-Impact Strategic Framework"

The **top plane** presents the System viewpoint. Enabling Programs and Technologies must become mutually reinforcing to support collective-impact success. Therefore, system-level, grade 4-12 continuum concepts must be addressed. The Network will focus on URMs, while addressing the topics shown in the top plane of Figure 1.

The five elements of Collective Impact permeate the Framework. Continuous Communication will occur between/across all planes (upward, downward, and in-plane) and with the Stakeholders, led primarily by the PI, and supported through the Local Backbone support including the EMERGEinSTEM.org website (described later). Early in the Pilot, Network partners will be gathered to come to agreement on a Common Agenda for the Pilot. MRAs will be cataloged for all of GC, and will fully populate the middle plane of the Framework. In the Barriers section on each plane of the Framework, one sees a Shared Measurement System mentioned. The Pilot will address this challenge, will aim to unify MRAs in their Measurement System that will produce data (following a robust, data-management plan/approach) that can be shared and valued across the entire Network and community. Last, the Local Backbone for this Pilot supports the entire Framework with a leader in charge of Project Management, meeting arrangements, communications between all parties, and maintenance of a powerful website. The backbone will leverage technology and social networking to unify the Network.

A gap exists between STEM skill development (bottom- and middle-planes), and real jobs in the STEM workforce (top-plane). The NC STEM Strategic Plan (North Carolina, 2011-2020) identifies programs devoted to teaching STEM fundamentals, but rarely mentions commensurate efforts to market STEM career job opportunities to students. Career-exposure elements added to MRAs, and use of Learning Blade (LB) game-based STEM and career education software for grades 6-8 will reduce the gap. Grade 6-8 students make early decisions about STEM careers (Joyce, 1999; Wyss, 2012; Tai, 2006; George, 2000; Caleon, 2008). Learning Blade has been favorably assessed by Battelle (Battelle Report, 2016), and is successfully used in TN (Tennessee STEM Innovation Network, 2015), AR (Arkansas, 2016), and Washington, DC (US DOE, 2016). LB use in GCS begins in May 2017 (funded through 2019 by PI's existing science-based outreach programs), and represents the first use of LB in NC. Data suggests that nearly twice as many students say they want to be Engineers or Scientists after using Learning Blade. ***The Pilot strategy*** is to expose learners, throughout their grade 4-12 education, to excite them about their future STEM workforce opportunities, with the aim of BP in the workforce.

Partners, Stakeholders, and Pilot leadership will meet regularly to drive success. The Network will use Stakeholder requirements to manage the system-level components of STEM education and research. Significantly-improved outcomes from EMERGE in STEM will occur through a diligent strategic approach. An increasing number of URM students will not only learn STEM fundamentals, but will also be personally excited about STEM career paths, thereby addressing BP challenges.

In addition to the strategic Framework, a Theory of Change (TOC) Strategic Model supporting the Pilot is shown in Figure 2. The TOC model shows a high-level view of the relationships between strategic efforts and activities, and expected outcomes. The TOC model relies on Collective Impact and links to the Framework to achieve desired outcomes on the far right of Figure 2.

A proposed Common Agenda for the Pilot is: to create supporting mechanisms for grade 4-12 URMs to enter and remain in STEM education pathways to the workforce by employing career knowledge and exposure elements in MRAs; and to demonstrate a regional, state, and nationwide approach to STEM-talent development that can be replicated in many other communities (through an Alliance).

Vocational Anticipatory Socialization (VAS, the process of learning about careers) Theory ties directly to the Pilot's TOC model. VAS has been used to study students' perceptions of the most influential sources and content of encouraging/discouraging career messages. VAS suggests that who delivers career messages, and what message is conveyed will help boost self-efficacy and outcome expectations, thereby helping students envision themselves in STEM career settings. Results suggest that mothers, followed by teachers/professors, friends, and fathers are perceived as the most influential encouraging VAS sources (Powers, 2016; Jahn, 2014a).

The types of messages adolescents receive, messages sources, and students' career frameworks (*enjoyment-based, ability-based, and goal-based)* affect their educational and vocational interests (Jahn, 2014b). There are generally two types of VAS messages: *personal fulfillment* (advising students to prioritize their well-being); and *career detail* (advising students about specific aspects of an occupation). Message givers, for instance, can affect student beliefs by talking about both personal fulfillment and career detail. Individuals in STEM occupations are in the best position to encourage students by offering career details,

discussing how their career can be rewarding, and how science classes can influence their career attainment.

EMERGE in STEM will use the findings from VAS to influence the design and implementation of Career messaging in MRAs. This approach is reflected in the lower right of the TOC Model, where it is noted that EMERGE in STEM seeks to understand *why change happens*. As career-exposure elements are incorporated into MRAs, what is communicated/taught, where it is taught, by whom and to whom it is taught, when it is taught by age group, and how/how much/how often it is taught will impact positive outcomes.

Throughout the Pilot, data will be collected (the what, where, who, when, how, how much, how often) so that the TOC Model will be assessed, and answers to *why change happened* will be answered.

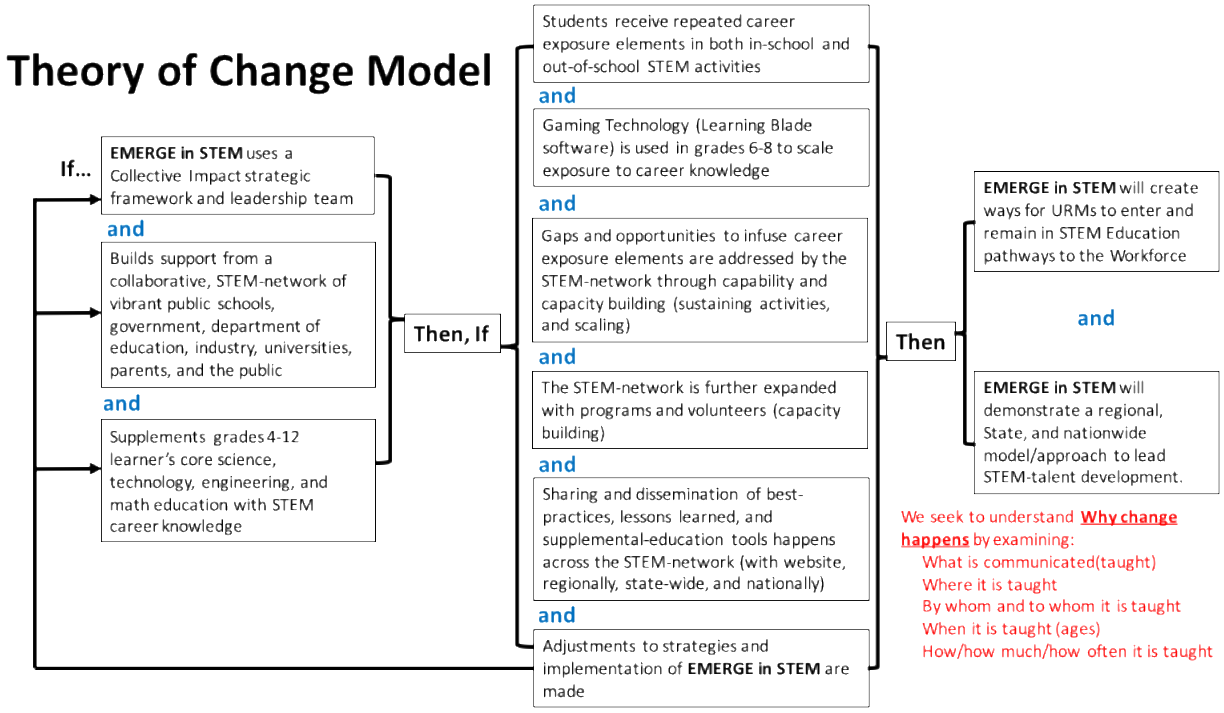

Figure 2. EMERGE in STEM Theory of Change Model

Intellectual Merit

The partnerships in this Pilot will use educational technology within a collective-impact framework to promote awareness and interest in STEM careers. This Pilot encompasses the potential to advance knowledge in understanding, designing, implementing, and assessing an innovative and transformative collective-impact model for STEM education. Data analysis and evaluation measures will be used to monitor, evaluate, validate, and refine each step in the Pilot to advance knowledge related to BP. The Pilot intentionally reuses local, successful STEM activities and interventions (MRAs), as baseline platforms. The Pilot leverages prior successes and brings STEM education in Guilford County to a much higher and purposeful level through collective impact approaches, adding significant merit and knowledge through career-exposure supplements to existing MRAs.

Use of a STEM-education and career-exposure software platform (LB, for grades 6-8) with a statistically-large population (~15,000 URMs including women could be engaged with LB during the Pilot) will produce informative data and knowledge not yet presented in the literature. Assessments will show the impact of career exposure on URM students (compared to non-URMs) including, in part: awareness of career opportunities, interest in pursuing STEM careers, and desire to take advanced STEM-based classes in high school and beyond. Leveraging the core concept of LB, career-exposure elements infused into MRAs throughout the grade 4-12 continuum will also be assessed to advance knowledge of infusion impact on URMs.

2. Partnerships

A broad network of strategic partners with strong diversity goals and varied perspectives from different sectors have been assembled for the Pilot: K-12 school district, community colleges, universities, local commerce and industry, entrepreneurial ecosystem, educational-software provider (from TN), government, and the NC Department of Education; to comprehensively solve a URM STEM-inclusion problem.

Guilford County Schools (GCS) was selected due to its large K-12 population (3rd in NC, ~72,000 students), and high poverty levels (63% economically disadvantaged; 45,000 K-12 students on free-meal programs; ~half are women). The demographic breakdown in GCS includes 40.6% African-American, 15.2% Hispanic, and 4% multi-racial students (Guilford County Schools by the Numbers, 2017). The Pilot will positively influence a large population of URMs. As many as 20,000 middle-school participants from ~23 Middle Schools, and ~15,000 URMs including women could use LB STEM software during the 2-year Pilot, and longer if used in an Alliance. The Pilot has also included the NC School of Deaf (see Broader Impacts section)

The strategic partners shown on the right side of Figure 1 represent the core network team along with the PI, co-PIs, and Senior Investigators. This core network team, or **Constellation**, is seen in Figure 3. Each **Star** of the Constellation represents a critical leadership organization in the network.

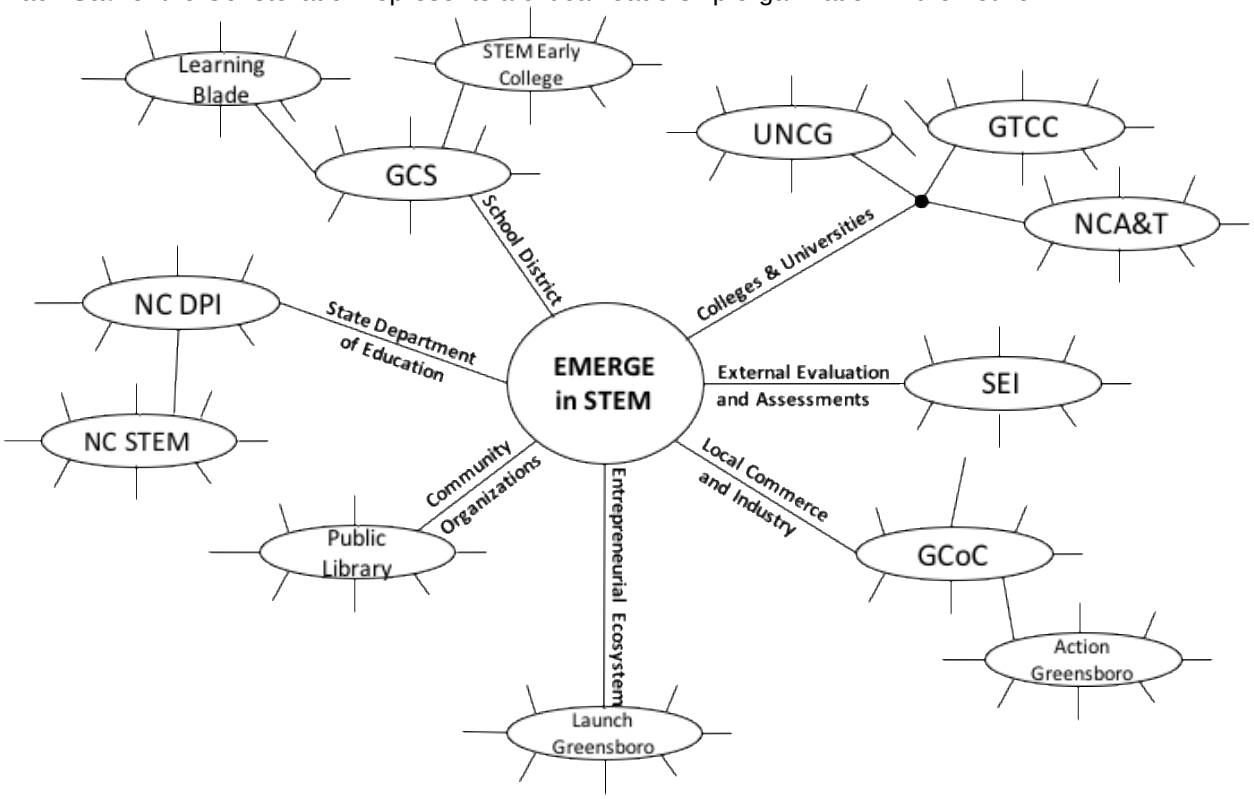

Figure 3. Constellation Diagram of Core Team of Partners and Pilot Leadership

The Constellation partners span the Framework (right side of Figure 1) from "Fundamental Knowledge" to "Enabling Programs and Technologies" to the "System-Level Education-to-Workforce Continuum." Selection of core partners was based upon having: (1) numerous, existing, local STEM MRAs; (2) large, local memberships of industry partners or individuals; (3) direct, local relationships to and vested interest in long-term STEM education pathways/pipeline from K-20; (4) ability to influence school systems across the state of NC; and/or (5) an established relationship with the PI. Partners represent organizations that either impact (provide resources to) or are impacted by (receive outputs from) the Framework. Core Partners have collective interest in workforce development for a wide variety of workforce jobs, and have an out-sized larger benefit from supporting this Pilot at their touchpoints. All partners have committed through support letters to this Pilot.

The Constellation diagram implies that contributions from the school district, colleges and universities, local commerce, the entrepreneurial ecosystem, community organizations, state education organizations,

and assessment experts all play a critical role in EMERGE in STEM success. Dangling 'connector lines' in Figure 3 represent the additional 'Stars' to be added to the Constellation, thus forming a complete '**Galaxy**' of partners. Each of the Constellation organizations have knowledge of or are associated with MRAs to be added to the Pilot, or have strong links to industry/entrepreneurs that depend upon a STEM-ready workforce to be successful. The Constellation members will identify and attract new 'stars' into the 'galaxy of partners' as the Pilot grows the network and adds capacity. *The Pilot will build a Galaxy that will brighten the future of STEM in Guilford County.*

Generally, each Constellation member (Core Leadership Team, and Partners) will be actively identifying MRAs to join the Galaxy, will participate in management meetings, and will help to recruit organizations and individuals to provide resources for career-exposure infusion to MRAs that don't already have this feature built in, or may need embellishment. Constellation members are critical to Capacity Building. An EMERGE in STEM work plan (and Management Plan structure) is shown later in Table 2. Thrust leaders and their management focus/activities are detailed in Table 2 for the 5 major elements of the Collective-Impact Model. The following list describes briefly the organizations and roles of each member of the Constellation:

EMERGE in STEM Core Leadership Team:

G. Monty, PI, NC A&T, College of Engineering, Director of the Center for Energy Research and Technology, Common Agenda and Continuous Communication Thrust Leader, and Collective-Impact Framework leader. Dr. Monty will lead most major meetings and will help the group iterate a common agenda and work plan. Dr. Monty has major funding in his center from the NC Department of Environmental Quality, primarily focused on Science and Energy educational outreach to GCS. Dr. Monty has established strong relationships with GCS administration (see support letter from GCS Superintendent), GCS Regional Science coordinators, curriculum facilitators in each school, and the teachers themselves.

M. Schug, Co-PI, Senior Investigator, UNC Greensboro, Associate Professor and Head of Biology Department, Faculty Facilitator for the RISE Network (Research and Instruction in STEM Education), and MRA Thrust Leader. Dr. Schug will lead the MRA efforts including identification of MRAs in Guilford County, and helping them add career exposure elements to their agendas.

M. Kanipes, Co-PI, NC A&T, Associate Professor of Chemistry, Director for the STEM Center of Excellence and Active Learning (where Dr. Kanipes leads evidence-driven STEM education course redesign/implementation; as well as teaching, learning and student success innovations/interventions), and Shared Measurement Systems (SMS) Thrust Leader. Dr. Kanipes will develop the assessment and metrics process. Survey form development, information gathering from validated assessment tools and surveys, and reporting of data analytics will be led by Dr. Kanipes.

S. Jiang, Co-PI, NC A&T, College of Engineering, will provide statistical data analysis. Dr. Jiang will work closely with Dr. Kanipes and D. Whittington on the Shared Measurement System (SMS), data collection and management.

D. Whittington, Senior Personnel, Strategic Evaluations, Inc. (SEI), is a STEM Educational Assessment expert with experience in collective impact, and is the Science-educator-grant External Evaluator (consultant) for the Pilot. His role will include assessment design, program evaluation, and reporting on results and progress from the Pilot.

V. Foust, Senior Personnel, NC A&T, Center for Energy Research and Technology, Research Associate and Local Backbone Thrust Leader. Dr. Foust will provide Pilot project management and communications support, will build and manage the website, and will coordinate reporting and meetings.

N. Exner, Senior Personnel, NC A&T, Information and Library Science, support for Local Backbone and SMS. Ms. Exner will also play a key role in broadly disseminating our Pilot results through the Library System in the region, state, and nation.

EMERGE in STEM Constellation Partners:

A. Holcombe, Guilford County Schools (GCS), Exec. Dir. of Strategic Planning & Technology. Key linkage into GCS, coordination using Learning Blade software in grades 6-8, alignment with teachers, administrators, and students throughout grades 4-12. Dr. Holcombe has worked with the PI in meetings with GCS leadership including: HR, Curriculum, IRB/Research Proposal process, Finance, Science Facilitators, and others in preparation for the EMERGE in STEM Pilot. Interaction with GCS is coordinated by Dr. Holcombe, as the first point of contact, with support from other educational professionals throughout the school system.

S. Boyington, Thinking Media, President, provider of Learning Blade software for grades 6-8. The software rollout has been coordinated and initiated with the PI and GCS. Initial LB introduction and training

(for Math, Science, and English teachers) will take place in Summer 2017, with expanded use planned in the pre-award phase. Full support of LB will be provided through S. Boyington.

J. Williams, GCS STEM Early College, Principal, will provide high-level STEM guidance for the Pilot efforts in GCS. The Early College has been recognized as one of less than 15 'STEM Schools of Distinction' in NC. The STEM Early College for grades 9-12 has extensive knowledge of the STEM education process in-school and out-of-school in GC. Dr. Williams will provide leadership to connect high schools across GCS, and to identify key MRAs in the region.

A. Jones, Guilford Technical Community College (GTCC), Project Coordinator/STEM Navigator (NSF Award #1400792, LSAMP Bridge to the Baccalaureate: NC STEM Alliance (NCSA)). Dr. Jones leads numerous STEM MRAs in grades 11-14. The LSAMP project focuses on supporting URMs in completion of an Associate of Science/Engineering, or Applied Associate of Science degree, with a transfer to a 4-year institution in a STEM degree field.

B. Christensen, Greensboro Chamber of Commerce (GCoC), CEO. The GCoC provides primary connection to the industrial and entrepreneurial collaborators that will provide career expectations, knowledge, and exposure to STEM learners in GCS. The membership of GCoC is extensive, and will be a key element of capacity building for the Pilot.

C. Thompson, Action Greensboro, Executive Director. This organization is part of GCoC and has a mission to work with the STEM supply chain to positively impact Greensboro and its companies.

L.A. Flanders-Stec, Launch Greensboro, VP of Entrepreneurship. Ms. Flanders-Stec leads many efforts with the entrepreneurial ecosystem in GC, which has been vibrant and growing. Launch Greensboro represents an excellent connection into a growth sector of GC, and an exciting destination for many of our STEM pathway learners. Launch Greensboro members will be leveraged to provide career exposure elements in MRAs.

C. Chappell, Greensboro Public Library, Chairperson, Board of Directors. The Library system provides out-of-school computer access to the community. GC STEM learners, may not have technology access at their homes, and will have that access in the Greensboro Library system to use LB, to use career-exposure online resources, and to complete assessments. The Library system also offers a wide variety of STEM MRAs to the community.

J. Honeycutt, NC Department of Public Instruction (NC DPI), Director, Career and Technical Education. Ms. Honeycutt coordinates STEM activities across NC for all public schools. Ms. Honeycutt will be instrumental in the dissemination (and Alliance scaling) of EMERGE in STEM results and successes across the state, and nationally through STEM organizations that she interfaces with.

S. Houston, NC STEM, Science and Mathematics Technical Education Center, Director. Dr. Houston coordinates STEM activities across NC with NC DPI. NCSTEM.org has an existing website that the Pilot will link to, coordinating and aligning activities from EMERGE in STEM. Collaboration with NC STEM helps the Pilot broadly disseminate results and successes across the state and nation.

3. Goals and Metrics

The Framework in Figure 1, aligned with the TOC Model in Figure 2 establishes the proposed strategic plan to address BP challenges to increase the number of URM students on a competitive trajectory in the grade 4-12 STEM continuum. Goals and objectives for the Pilot are listed below.

Goals of the Pilot include:

- Raising the number and percentage of URMs in the STEM Pathway all the way to the Workforce
- Building a local STEM-ready talent pipeline
- Designing/Implementing/Demonstrating a Collective Impact Strategy for STEM (in Guilford County) that is transferrable to other communities across NC and the nation

Specific Objectives of the Pilot include:

- Objective 1: Build a Network (Leadership team, Partners, and Stakeholders) focused on URMs in STEM; supported by a Collective Impact strategy.
- Objective 2: Increase STEM collective impact with career-exposure strategies to grow attention, interest, desire and action of students, thereby broadening participation in STEM pathways.
- Objective 3: Develop a Shared Measurement System and Assessment Process to evaluate the career-exposure strategies and implementation for MRAs in grades 4-12.

In support of these Pilot Goals and Objectives, and aligned with the Framework and TOC Model, a Logic Model shown in Table 1 was developed. Immediate outputs, intermediate outcomes, and longer-term outcomes are detailed in the Logic Model. Mediating individual and organizational factors/challenges

are also noted. A major section of the Logic Model dealing with Activities and the Pilot Work Plan is further detailed in Table 2. This Pilot is visionary, but also will be realistic in scope: prioritization and selection processes will be used to address highest-impact touchpoints along STEM pathways.

Table 1: Logic Model for EMERGE in STEM

Inputs	Activities/ Work Plan	Outputs	Mediating Individual Factors	Intermediate Outcomes	Mediating Organizational Factors	Longer-term Outcomes
Promising Students	See EMERGE in STEM Work Plan in Table 2.	Students see value of STEM careers and establish measurable personal goals	Student self-efficacy and confidence lacking	Enhanced academic performance of Students in STEM	Need for a sustainable volunteer/support network related to careers	Capabilities and Capacity of Students in STEM is increased
Varied Educational Experience		Student relationships to Industry and along STEM pathway formed	STEM knowledge and skills matched to actual jobs	Students participate in multiple MRAs	Budgetary constraints of network partners	Increased Number and Percentage of URMs in STEM Pathways
Prior Career Guidance		Students have improved STEM-related knowledge and skills	Costs to participate in MRAs	Continuation on STEM Pathways	Expanding MRAs to fill gaps will require resources	Increased Number and percentage of URMs enter STEM workforce, and remain in Workforce
Perceptions of Options for their pathways		Students gain career knowledge and awareness	Adding career exposure to existing/established MRAs may be challenging	Positive attitudes toward STEM		Regional/State/National community use best practice model from EMERGE in STEM
Facilities to support STEM activities		Students gain self-efficacy, sense of belonging, and competence		Lasting connections & collaborations at all levels in education system		EMERGE in STEM build a Collective Impact Alliance, and demonstrates that model can supplement STEM education in communities across State and Nation
Identified STEM Workforce needs		MRA leaders understand gaps in programs related to career exposure, increase collaboration and intentionality		Increased support from across community		Regional/State/National community and education system increases capacity/capability
STEM-concerned community members		Comprehensive document describing MRAs		Capacity building begins to take shape across community (added MRAs, volunteer resources, career exposure resources developed)		
Socioeconomic status of many URMs is challenged		Parents/Teachers/Administrators gain knowledge of STEM Careers		High School grads continue education on STEM Pathway in college, or enter STEM jobs		
		Website built including complete and searchable Calendar of MRAs		Parents/Teachers/Administrators learn what/how to communicate career information to students		
		Website becomes communications platform for EMERGE in STEM network		Increased attention, interest, desire, and action by Students in STEM pathways		

The Emerge in STEM Work Plan in Table 2 details specific steps and activities along the timeline of the Pilot from pre-award activity through years one and two. Activities in the work plan have been segmented (the management structure for the Pilot) along the 5 strategic efforts of Collective Impact, with the PI, co-PIs, and senior personnel leading those Thrust areas. The Local Backbone effort will be responsible for Project Management documentation, and reporting on completion of milestones in the Work Plan. The PI and the Local Backbone leadership (physically co-located) will work closely together to continuously communicate broadly across the Pilot network (Galaxy), and to keep the Pilot on schedule. Two co-PIs are responsible for Major Thrust areas of MRAs and the SMS.

Major responsibilities in each Thrust area:

Common Agenda

- Draft final Common Agenda statement to support the Pilot concept: adding career exposure elements to MRAs will lead to positive outcomes for URMs along the STEM pathway
- Conduct regular management reviews to assess the Pilot and make changes as needed
- Gain support and agreement to build capacity by establishing a volunteer resource system to support the collective impact strategy

Continuous Communication

- Complete Research Proposal to GCS, and IRB process at NC A&T by September 2017
- Schedule and lead management meetings for Pilot, to increase collaboration and support, and to define improvements and changes
- Insure that communications across the Galaxy of participants is effective
- Work with the Local Backbone to share results locally, regionally, and across the state and nation

Mutually Reinforcing Activities

- Identify the STEM activities (MRAs) in GC to be included in the Pilot
- Gather information from the MRAs, and establish that information in the EMERGEinSTEM.org website, and enable access to the MRAs with a searchable calendar for students and the public
- Insure that MRAs are using a common pre- and post-assessment approach to evaluate the impact of career-exposure elements on participants
- Work with individual MRA leaders to define gaps and opportunities to improve the overall STEM education system in GC, and define ways to make appropriate changes

Table 2: EMERGE in STEM Work Plan (Objectives and Steps in support of Project Goals)							
Collective Impact Thrust Area	**Pre-award**	**Y1 2018**			**Y2 2019**		
		Spring	**Summer**	**Fall**	**Spring**	**Summer**	**Fall**
Common Agenda (Dr. Greg Monty, PI)		Agree on Collective Impact Strategy & Common Agenda (committed partners, Constellation MOUs signed)		Y1 Mgmt Review: Reaffirm Common Agenda (Refine structure and Strategy)			Y2 Mgmt Review: Reaffirm Common Agenda (Refine structure and Strategy)
		Evaluate Career-Exposure Elements (CEEs) of MRAs	MRA leaders agree to add Career-Exposure Elements to their programs				
		Plan how to supplement existing MRAs with CEEs	Constellation/Galaxy partners research to find existing approaches for career exposure that could be used in our project (cost-effective, re-use)				
		Build concept of Volunteerism in Constellation and Galaxy	Create Collective Impact Constellation and Galaxy that cares	Galaxy Integration, Increase Access to shared resources	Build Galaxy Volunteerism Support across Guilford County		
	Identify/recruit additional core constellation partners, galaxy partners, and Stakeholders, as needed						
Continuous Communications (Dr. Greg Monty, PI)	Schedule Team Mtgs for Y1-Spring	Conduct Core Pilot Leadership Team Mtgs	Leadership Team Meetings Quarterly (refine structure and startegy as needed)				
	IRB with NC A&T approved	Conduct Constellation Partner's Mtgs	Constellation and Galaxy partner Meetings held Quarterly				
	Research Proposal with Guilford County Schools approved	Build and Facilitate Collaboration across Leadership Team, Constellation, and Galaxy					
		Publish on Web Site: Common Agenda and Vision Documents, Requirements Document from Stakeholders, Agreements, Plans, Results (Best Practices, Lessons Learned, and How-to Manual for other communities to replicate)					
				Share Pilot Results across State of NC, Nationally, and with NSF			
Mutually Reinforcing Activities (Dr. Malcolm Schug, Co-PI)	Launch Learning Blade in ALL GCS Middle Schools	Learning Blade Use Ramps Up					
	Train Teachers on Learning Blade	Develop Surveys forms about MRAs (for website)					
	Launch Learning Blade in School for the Deaf	Catalog MRAs in Guilford County	Develop comprehensive document describing MRAs (what, why, who, where, when, how, how much, how often?)				
		Display MRAs in searchable Web Site Calendar	Established Baseline MRAs				
		Identify Barriers, Opportunities for Change/Improvement					
		Discuss Content & Resources for MRAs	Address Barriers and Opportunities to Improve (eliminate duplication, add value)				
		MRAs active across Guilford County, with Pre- and Post-Assessments					
Shared Metrics (Dr. Margaret Kanipes, Co-PI)	Build Assessment Instruments/Tools, and Survey Questions (from existing Friday Institute/NCSU validated assessment tools, plus participant and MRA information survey form)		Evaluate Preliminary Assessment Data	Program Mgmt Reviews: Use data to learn, improve, and refine strategies, activities, and metrics			
	Set up online Assessment (computer, mobile, and tablet accessible)	Validate on-line assessment data collection process	Identify issues and gaps				
	Any Students in GCS that begin using LB take Pre-Assessment	Gain MRA leader's agreement to use Assessment tool	MRAs administer Pre- and Post-assessments; run data analytics, reports on Impact of Career Exposure				
Local Backbone (Dr. Vicki Foust, and Nina Exner, Senior Investigators)	Develop Web Mock-up	Build Web Site with WordPress	Continuously update Website with Project info, Progress Reports, Info about Volunteer network, and Resources for all EMERGE in STEM partners, stakeholders, and participants				
	Set up Data Management System, including Student registration	Populate Web Site Calendar with MRAs					
		Backbone Website fully functional, and supporting Project					

<u>Shared Measurement System</u>

- Define the assessment approach to use in the Pilot (collaboratively with the External Evaluator and the internal co-PI data analytics expert)
- Build the assessment tools and other survey instruments, and install them in the EMERGEinSTEM.org website (with computer, tablet, and mobile phone accessibility)
- Gain Galaxy acceptance of assessment and survey tools, and drive usage
- Evaluate assessment data, and make appropriate strategic changes to the Pilot as needed

<u>Local Backbone</u>

- Define and build the EMERGEinSTEM.org website to support the Pilot. Figure 5 is a simple mockup of the website design. Wordpress will be used, and the site will be functional by Jan 2018.
- Define and build a functional project management process to support the Pilot
- Communicate to the entire network regularly, and disseminate Pilot accomplishments broadly with the Network and externally across the state and nation

Notes for EMERGE in STEM work plan:

Data will be collected primarily from student participants; leaders of STEM MRAs; and from constellation and galaxy partners. Online surveys and questionnaires will be used to automatically collect data. The EMERGEinSTEM.org website (Figure 5) will be used for this purpose, and it will be accessible from computers, tablets, and mobile phones. Students that participate in numerous STEM MRAs during the Pilot will do pre- and post-assessments (with a first page that includes consent) for each formal intervention that requires registration. Students will answer basic demographic survey questions on only their first assessment within the Pilot, and will be given a userID and password to keep their identity anonymous. Additional assessments will require only a log-in. The final student assessment will collect information about MRAs participation that did not include registration (such as teacher career discussions, school career counseling, industry presentations in the classroom, and others). Leaders of MRAs will enter data to catalog and advertise their events for the public in the calendar/events section of the website. Additional data will be gathered by the external evaluator, D. Whittington (SEI), from across the network to assess Pilot performance.

IRB and GCS Research Proposal process: GCS requires the Pilot submit a Research Proposal to a committee for approval before beginning. An Institutional Review Board (IRB, category 1 for research conducted in an established educational setting) will be completed with NC A&T. Since the major assessment tools from MISO have been used with ~20,000 students and over 100 programs, there don't appear to be any major approval issues. The PI expects approval from GCS (draft proposal 90% completed) and the IRB (working directly with NC A&T Div. of Research & Economic Development now) before the end of September 2017. The PI has held high-level meetings with Amy Holcomb, Executive Director of Strategic Planning and Development for GCS, and GCS leaders of HR, Finance, Curriculum, Review Board, and Science coordination. GCS administration is helping the PI through the process.

***External Evaluator, Qualifications and Progress Indicator Measurements*:** Strategic Evaluations, Inc. (SEI) will serve as the coordinator of the overall assessment of the Pilot. Strategic Evaluations, Inc. (SEI) is an evaluation consulting firm located in Durham, North Carolina that specializes in evaluating science education grants and is familiar with collective-impact models. The firm's current evaluation work includes directing several initiatives built around similar goals of increasing engagement, retention, and advancement for underrepresented students in the sciences across more than 20 institutions throughout the country. SEI's role in coordinating the overall assessment will involve the following main responsibilities:

Assisting with the design and implementation of the Shared Measurement System

SEI will work closely with Drs. Jiang and Kanipes on the development of the Shared Measurement System. SEI will provide input for the variables that are required for users' entry, both for partner representatives as well as students. The evaluation team will advise on site-based metrics that will be included in the background design of the web platform (Figure 5).

Assessing the effectiveness of the Learning Blade Software rollout and usage/adoption

SEI will assess Thinking Media's LB-software rollout in Guilford County Schools, reporting metrics such as number of schools, school demographics, and grade-level usage for the software. SEI will ensure data being collected by Dr. Boyington's team aligns with data needs for evaluating the overall Pilot, e.g, percent of students at each level successfully completing modules with career awareness elements. SEI will further disaggregate the data collected so that questions beyond the scope of Thinking Media's interests can be explored. For example, while Thinking Media will be expected to produce school-level reports for classrooms using the software, SEI will integrate these school-level reports into the team's broader data set to answer additional questions, such as teacher fidelity of implementing the software in relation to growth.

Monitoring the large-scale, mixed-methods research design

The overall assessment of the Pilot will include a strong mixed-methods research design, led by Dr. Jiang but monitored by SEI. The research design will have a dual focus.

Direct Student Impact

Two cohort groups of students (URM and non-URM) will be identified. Both pre- and post- data points will be collected across all student participants using the MISO Upper Elementary S-STEM Survey and the MISO Middle/High S-STEM Survey (Friday Institute, 2012a and 2012b). These survey instruments have been validated and will be administered to measure student awareness of career opportunities, attitude towards science, math, engineering and technology and 21st century skills, and interest in pursuing STEM careers. In addition to key demographics, student attitudes are measured using a five-point Likert scale, and student interest in STEM careers are measured using a four-point Likert scale. Survey items will be

developed and added to the pre- and post-surveys to help document areas that are currently uncovered on the S-STEM survey, e.g. students' sense of belonging and VAS-related items like encouraging/discouraging career messages students have encountered. While these items may not have been validated, our expectation is to work with a sample size large enough that these Pilot efforts can add to the literature by validating additional survey items that align with our objectives.

Descriptive statistics such as mean, standard deviation, and frequency will be computed for the sample set. Inferential statistics such as unpaired t-test will be conducted to compare construct (student attitude on STEM, and 21st century skills) scores aggregated across the cohort group, grade level, gender, and across all school levels. The nonparametric Mann-Whitney test will be performed on student interest in STEM career. A significance level of 0.05 will be selected for all hypothesis testing.

In addition, multivariate statistical techniques such as profile analysis will be performed on student attitude and interest in STEM careers for the URM group and the non-URM group. Profile analysis will be performed to address the following research questions: (1) overall, is there any statistical difference in terms of student attitude (or student interest) between URM and non-URM participants? (2) Are the profiles of the two groups parallel? In other words, are the differences between the attitude scores (i.e., attitude towards math vs. science, attitude towards science vs. engineering and technology) the same for both groups? (3) Is the profile flat? In other words, are the attitude scores (STEM, 21st Century skills) the same? Results from the profile analysis will reveal the patterns in each student group and can be used to improve the STEM activities (MRAs used beyond the Pilot, in other communities, or potentially in an Alliance).

For student interest data, exploratory statistical techniques such as cluster analysis will also be performed. Cluster analysis can group items based on similarity data. Results from this analysis will reveal how student interests in STEM Careers are grouped and findings can be used to revise the activities to improve the effectiveness of the Pilot.

Lessons Learned Regarding Theory of Change

An additional benefit from having student-level participation and interest data stored along with descriptive data for the multiple types of MRAs (e.g., summer camps, workshops, career fairs, etc.) is that the combined dataset will allow us to further explore the level of impact different types of MRAs are having on the changes that are documented among students. The Pilot expects the volume of data (many thousands of student participation records, along with career-interest data collected through a validated survey and descriptive data on likely 30-70 different MRAs) to enable us to uniquely contribute knowledge to the Theory of Change model. The research design will focus on understanding "why change happens' and if categories or quantities of MRAs significantly contribute to these changes.

Leading the data collection activities and analysis of anonymous data from stakeholders:

SEI will gather data directly from the Partners, Stakeholders, and Pilot leadership. SEI will design and implement an independent component that will serve as the "arms-length" external evaluation, in which data that are more sensitive in nature and benefit from anonymity, are collected and analyzed in relation to the objectives stated for this Pilot, especially the initial objective, which is to build a Network focused on URMs in STEM that support the Collective Impact model.

The evaluation team's approach will emphasize the design of several survey instruments that will be administered at regular time intervals for both formative and summative assessment of Pilot outcomes. The data will be analyzed according to specific outcome measures and presented to Pilot leaders and other stakeholders for review and discussion. Questionnaires for collecting quantitative data from Partners, Stakeholders, and Pilot leadership will include electronic surveys to document the quality and usefulness of grant-sponsored activities. All survey data will be stored and analyzed using IBM SPSS. Qualitative data will also be collected through face-to-face focus group interviews with Partners, Stakeholders, and Pilot leadership to document the quality and impact of the Network. The focus group sessions will be guided by an established protocol that the IRB will review and approve. All interview data and open-ended comments from surveys will be transcribed, coded, and analyzed in *Atlas.ti* (qualitative analysis software) for themes.

For example, this component of the evaluation will include focus group interviews with key network partners. Each focus group will be expected to last approximately 60 minutes and will be audio recorded and transcribed (with participant approval). The protocol will focus on the priorities of the partnership, partners' level of engagement within the network, the strengths and challenges associated with the partnership, the added value of the partnership, and how to best position the partnership for maximum impact for students in Guilford County.

Network partners will be asked to complete the Partnership Self-Assessment Tool developed by the Center for the Advancement of Collaborative Strategies in Health at the New York Academy of Medicine

on an annual basis. This tool is designed to measure partnership synergy which is the "power to combine the perspectives, resources, and skills of a group of people and organizations." (Lasker, 2001). This tool measures the partnership's: level of synergy, leadership, efficiency, administration and management, nonfinancial resources, and financial resources (Figure 4).

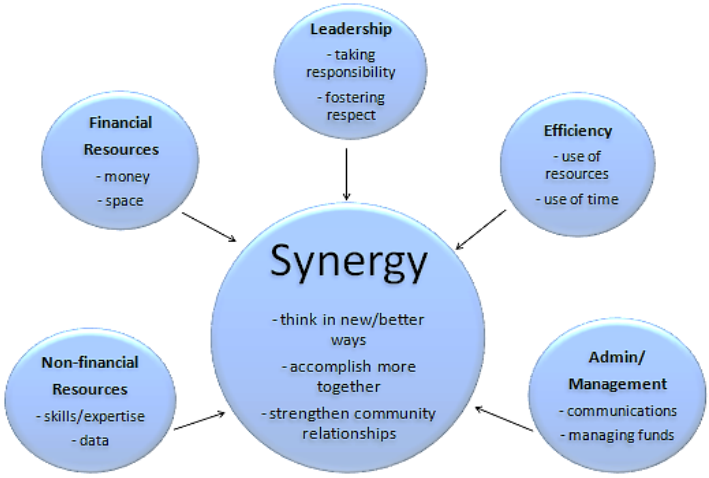

Figure 4. Domains of Partnership Synergy

To further assess the Network, all partners will be asked to complete an annual online survey aimed at gathering information on their collaborative efforts within the partnership. Respondents will be asked to: (1) rate the partnership's level of collaboration on a collaboration continuum (Himmelman, 2002); (2) identify which network partners they currently/have-recently worked with on issues related to the shared goals of the partnership; and (3) indicate whether or not the responding organization has worked with a partner in any of four key ways—exchanging information, referring individuals, sharing financial or non-financial resources, and providing joint services (Wells, 2015). In addition, respondents will also be asked specific questions related to their satisfaction with the partnership and likelihood of remaining involved. These data will complement the hard metrics in documenting the overall success of the Pilot.

Evaluation Reporting:

Evaluation will include written informal summaries for focus-group interviews and descriptive data tables for every set of survey data collected. At the close of the Pilot, the evaluator will prepare a summative report for leaders to use in documenting impact to their stakeholders. This summative report will include data from all evaluation activities, including highlights of the implementation of the Learning Blade Software and conclusions that are able to be drawn from the mixed-methods study.

Demonstrated success of Objectives 1-3 will position the Pilot to be used in many other networked STEM-improvement communities across the state/nation. Demonstration of a successful Network and Framework, combined with proof of a successful TOC-Model, with career-exposure strategies supported by a shared measurement system will establish this Pilot as a transformative approach that addresses the broadening participation challenges.

4. Leadership and Communication

The Pilot will demonstrate leadership capacity and joint action as: knowledge is gathered; resources for MRAs are enlisted; alignment is achieved across the Galaxy; and institutionalized processes are in established (Emerson, 2012). Continuous Communications, a critical element of Collective Impact, is fundamental to the Framework, TOC Model, Logic Model, and Work Plan (including Management Structure). Notably, frequent communications insure "stakeholder requirements" are clearly understood, and that the STEM Resources and Outcomes from the pilot meet the "requirements." Stakeholders will be engaged in leadership meetings, particularly industry representatives who will ultimately hire STEM graduates. Meetings with Constellation/Galaxy partners and Stakeholders will keep the Pilot focused on its goals and objectives, and will support strategy and implementation changes as needed. State education organizations such as the NC DPI, NC STEM, and their collaborators will help to spread success stories and best practices broadly. The broad "galaxy of partners" established will afford numerous communication and dissemination opportunities with their constituents and memberships, thus demonstrating collective

leadership from the Pilot. Results from the Pilot (particularly the impact of STEM-career-opportunity exposure for URMs in the 4-12 continuum) will be shared broadly among partners and beyond (publications, conferences, web-meetings, EMERGEinSTEM.org website, NCSTEM.org website).

Figure 5. Mockup of EMERGEinSTEM.org Wordpress website design

The Stars-to-Constellation-to-Galaxy model will rapidly build capacity across Guilford County. The initial Constellation has about 13 Stars, and will quickly grow to 30-70^{+} as MRAs are added. Leadership by the Constellation will also help to identify and attract leaders and volunteers from industry, the entrepreneurial ecosystem, and the STEM-workforce community. The Constellation partners have large memberships, established relationships, and capacity to communicate with their constituency. EMERGE in STEM will leverage those relationships to build out the Galaxy of partners. More importantly, as the Pilot begins, gaps, barriers, and opportunities for improvement and change will arise (related to STEM career exposure). The creative leadership of the Constellation and Galaxy will offer opportunities for working groups to address those opportunities with creative ideas, processes, and volunteer resources. Creative financial models and ideas that attract URMs to participate will be expected from these work groups.

The Core Leadership team will develop a Common Agenda with the Constellation partners, and has built formal Project/Program Management Reviews into the Work Plan. These meetings will be used to adjustment and improve the overall process.

The main mechanisms for sharing information within the Galaxy will be regular meetings, email communications, and the EMERGEinSTEM.org website. A major element of that website will be the MRAs Events Calendar. For the first time in Guilford County, there will be a comprehensive STEM website to build and share capacity across the community. This calendar will be a searchable location to share/list STEM activities, and for the entire GC community, particularly students, to find STEM activities to participate in. All Constellation and Galaxy partners will direct their memberships and constituents to the website as a Go-To hub of STEM information for GC. The local website information will be linked to and shared directly with the state (NC DPI, and NC STEM), and through them with national STEM education organizations. The public will be able to sign up for a monthly email/blog post about the EMERGE in STEM Pilot. Since no central information web portal exists in GC today, this contribution of a comprehensive STEM website hub will truly leverage the communities' knowledge for STEM development.

Social media will also be used to communicate broadly across GC. A twitter address @EMERGEinSTEM, and a hashtag #EMERGEinSTEM have been established to increase shared communication across GC and the Galaxy of partners. To facilitate the assessment process throughout

GC for MRAs, 50 Amazon Fire tablets will be available to easily collect assessment data. These tablets are owned by the PI's Center for Energy Research and Technology, and will be made available to all MRAs.

In support of the Framework in Figure 1 and Work Plan in Table 2, an organizational structure will draw leadership from Partners and Stakeholders. Grades 4-12 will be segmented into 3 groups: 4-5; middle school grades 6-8; and high school grades 9-12. Intersecting these school age-groups will be 3 Thrust areas: Common Agenda and Continuous Communication (CACC), led by PI, Dr. Monty; Mutually Reinforcing Activities (MRAs), led by UNCG lead investigator, Dr. Schug; and Shared Measurement Systems (SMS), led by NCA&T co-PI, Dr. Kanipes. Dr. Foust provides Local Backbone leadership for the Pilot. Intersections of the Thrust areas with the school age-groups are opportunities to collaborate (work groups) with partnering organizations, Stakeholders and MRA champions to build capacity for leadership across the Pilot Network. Volunteer leadership development will be a focus of the leadership team.

5. Potential for Expansion, Impact and Scale

Impact and scale was designed into this Pilot's Framework for broadening participation. There is potential for replication and scaling of not only the LB platform, but also the other MRAs for STEM education and career exploration. As the Framework is a "supplementary," system-based process that infuses career-exposure elements into existing MRAs, it can be adapted to virtually any community that has STEM-related, URM-focused educational programs and activities. The Framework is an excellent vehicle to use for Alliance leadership. STEM-fundamental-education-based URM programs across the nation can benefit from an infusion of career exposure at levels throughout the grade 4-12 continuum.

Output of this Pilot will include a Collective-Impact Strategic Framework "process" that can be replicated in other communities across the nation (those with school systems, colleges, industries, Chambers of Commerce, and state Departments of Education). A documented process will be produced and disseminated through the EMERGEinSTEM.org website that describes: (1) how to form a leadership team with partners; (2) how to catalog local STEM MRAs; (3) how to establish a common agenda, vision, goals, and objectives complete with career-exposure elements for MRAs; (4) lessons learned and best practices for infusing career-exposure into STEM MRAs throughout the grade 4-12 continuum; (5) what and how to perform assessments and measure success using a shared measurement system; and (6) how to establish a local backbone organization to manage the Framework implementation with meetings and continuous communications. Numerous resources and tools used in this Pilot will be available on the website. The goal is to establish a one-stop-shop that provides a complete 'How-to Manual' for use across the nation.

Specific resources and tools that will be made available to organizations across NC and the nation include, in part: the survey and assessment instruments used by EMERGE in STEM; an exact copy of the core website for replication in other communities; creative methods to attract volunteers to the network, and creative processes to lower the cost of URM participation in STEM MRAs. The Pilot's goal is to be able to transfer the entire website and its contents broadly across the nation, and in an Alliance. The PI will personally consult with any community replicating EMERGE in STEM's success.

Partners that have statewide reach and relationships will be leveraged to disseminate Pilot outputs, outcomes, and successes. Pilot university/college, library, NC DPI, and NC STEM partners have nationwide networks to be leveraged for dissemination and Alliance building.

Cost-effectiveness was also considered in scale design. Since LB costs only about $1-2/student/year, it can be implemented cost-effectively. Infusion of STEM career-exposure elements into existing MRAs can be done with very little expense by replicating shared best practices, and by taking advantage of existing online career-exposure resources. The Pilot will re-use and leverage extensive established resources for career exposure already available on the internet (videos, interviews, blogs of/from people with STEM careers (Videos, 2017)).

Broader Impacts

EMERGE in STEM has high potential to broaden participation in STEM because NC A&T is leveraging network partners currently engaged with targeted URMs including women. The societal benefits and outcomes from this STEM Pilot include:

- increased participation of women, URMs, and persons with disabilities *(LB displays all spoken words; educationally effective for Deaf students who will participate in this Pilot. Deaf students rarely choose to join STEM programs, mainly because of a lack of adequate exposure and understanding about future careers and opportunities in STEM fields (Schroedel, 2007; Perkins, 2007). See Support letter from NSF SEEDS program (Science and Engineering Enrichment for K-12 Deaf Students, Dr. Fini, NC A&T);*

The North Carolina School of Deaf, Morganton, NC will be a partner in this program, and will use LB. This school has been in the NC A&T SEEDS program with Dr. Fini since 2011 (initially supported by NSF Career award #1150695).

- improved STEM education and educator development for grades 4-12 *(teachers and administrators will be supported by this Pilot to infuse career exposure into their STEM programs in-school and out-of-school; Middle School teachers in GCS will learn and use Learning Blade STEM software, which may become a standard across the state of NC with Pilot success);*
- increased public engagement with science and technology from parents and community *(thru education, counseling, and communications, the Pilot intends to help the community and parents, particularly, deliver the right messages to students. Additionally, the Pilot will be widely advertised in GC, giving the entire community of GC opportunity to engage more with STEM);*
- improved well-being of individuals in society *(STEM job preparation, or continuation of STEM in college toward the STEM workforce);*
- development of a diverse, globally competitive STEM workforce *(URM focus of Pilot, the Pilot should grow the number and percentage of URMs staying in STEM pathways all the way to the workforce);*
- increased partnerships between academia, industry, and others *(a Galaxy of partners and volunteers will be formed that will grow capacity in GC, and improve STEM output from the education system);* and
- enhanced infrastructure for research and education *(the Pilot is expected to be leveraged into a national Alliance, and will make available a full set of tools and resources that can be replicated (copied nearly exactly) across the nation).*

Results from Prior NSF Support

NSF/HRD-1409799 (8/15/2014-7/31/2019) "***NC A&T ADVANCE Institutional Transformation: Catalyzing Gender, Leadership, and Scholarship Equity through Institutional Change for All***" (PI: Joe Whitehead, Jr., **Co-PI: Margaret Kanipes**; Award Amount: $3,638,800). The underrepresentation of women in senior professorial and administrative roles at HBCUs chronicles significant inequities. NC A&T was awarded an ADVANCE Institutional Transformation project aimed at catalyzing university-wide systemic changes that increase the representation of women. The project provides STEM women faculty (n= 16 scholars to date) with novel opportunities (e.g. creating professional development plans with mentors and visiting funding agencies). **Intellectual Meri**t: Increase knowledge on gender inequity at HBCUs (under-researched field). **Broader Impact:** Increase opportunities for training mentorship and advancement for minority females.

NSF/DUE -1525673 (10/2015-9/2018) "***Redesigning General Chemistry- Implementation of Emporium Learning for Enhancing Basic General Chemistry Skills***" (PI: Marion Franks, **Co-PI: Margaret Kanipes** $582,607). The Chemistry Department is redesigning general chemistry courses to implement emporium learning: active student-learning through interactive software with guidance from instructors. A pilot version saw a dramatic increase in the percentage of students earning A's in the course (5% traditional, 40% emporium). Each faculty member will teach both a traditional model and an emporium model and assess student performance with common pre- and post-tests, and surveys. **Intellectual Merit:** Novel active learning method. **Broader Impact:** Increase student success in gateway courses.

NSF/CMMI – 1000018 and 1000282 (5/2010-4/2014) **"Collaborative Research: Engineering Efficient and Equitable Food Distribution Under Uncertainty"** (PI: Lauren Davis, **Co-PI: Dr. Steven Jiang** $196,247). **Intellectual Merit:** This research addressed decision making under supply and demand information uncertainty in the non-profit food distribution environment. Predictive models were developed to characterize in-kind donation behavior, and to estimate the demand for food. Optimization models were developed to increase access to and equity of distributed food. **Broader Impacts:** Substantial benefits to society will be realized through improved supply allocation and donations management for non-profit hunger relief agencies. This project supported the research work of 23 domestic and international students at the undergraduate, graduate, and doctoral level with 61% female and 43% underrepresented minority participation. *Four publications resulted from this work.*