Board 65: Work in Progress: Growing and Sustaining a Successful Collaboration of Programs Developing and Implementing Experimental Centric Pedagogy

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Dr. Sacharia Albin joined Norfolk State University in July 2011 as the Chair of the Engineering Department. He received his BS and MS degrees from the University of Kerala, and Ph.D. from the University of Poona, India. He was a design engineer in microelectronics at Hindustan Aeronautics, India for three years. He was awarded a Post-Doctoral Research Fellowship by the Science and Engineering Research Council at the University of Liverpool, UK. Dr. Albin conducted research on Si and GaAs electronic devices and semiconductor lasers at the research laboratories of GEC and ITT and published numerous articles in this field. He was a professor of Electrical and Computer Engineering at Dominion University. He has advised 14 PhD and 19 MS students. He received numerous awards: Doctoral Mentor Award 2010; Excellence in Teaching Award 2009; Most Inspiring Faculty Award 2008; Excellence in Research Award 2004; and Certificate of Recognition for Research - NASA, 1994. He is a Senior Member of the IEEE and a Member of the Electrochemical Society.

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Dr. Petru Andrei is Professor in the Department of Electrical and Computer Engineering at the Florida A&M University and Florida Stat University (FAMU-FSU) College of Engineering. He is the FSU campus education director for the NSF-ERC Future Renewable Electric Energy Delivery and Management Systems Center (FREEDM) and has much experience in recruiting and advising graduate, undergraduate, REU, and K-12 students, as well as in working with RET teachers. Dr. Andrei has published over 100 articles in computational electronics, electromagnetics, energy storage devices, and large scale systems.

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Dr. John Okyere Attia is Professor of the Electrical and Computer Engineering at Prairie View A&M University. He teaches graduate and undergraduate courses in Electrical and Computer Engineering in the field of Electronics, Circuit Analysis, Instrumentation Systems, and VLSI/ULSI Design. Dr. Attia earned

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Dr. Mohamed Chouikha is a professor and chair of the Department of Electrical and Computer Engineering at Howard University. He received his M.S. and Ph.D. in Electrical Engineering from the University of Colorado–Boulder. Dr. Chouikha's research interests include machine learning, intelligent control, and multimedia signal processing communications for secure networks, among other areas. He also focuses on enhancing recruitment and retention of underrepresented minorities in the STEM areas in general, engineering in particular.

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Dr. Shonda L. Bernadin is an associate professor of Electrical Engineering in the Department of Electrical and Computer Engineering at the FAMU-FSU College of Engineering. Dr. Bernadin received her B.S. in Electrical Engineering from Florida A&M University, her M.S. in Electrical and Computer Engineering from University of Florida, and her Ph.D. from the Department of Electrical and Computer Engineering at Florida State University in 2003. Her research interests include speech signal processing, driver-vehicle interfacing, and engineering education.

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Kenneth Connor is an emeritus professor in the Department of Electrical, Computer, and Systems Engineering (ECSE) at Rensselaer Polytechnic Institute (RPI) where he taught courses on electromagnetics, electronics and instrumentation, plasma physics, electric power, and general engineering. His research involves plasma physics, electromagnetics, photonics, biomedical sensors, engineering education, diversity in the engineering workforce, and technology enhanced learning. He learned problem solving from his father (who ran a gray iron foundry), his mother (a nurse) and grandparents (dairy farmers). He has had the great good fortune to always work with amazing people, most recently professors teaching circuits and electronics from 13 HBCU ECE programs and the faculty, staff and students of the Lighting Enabled Systems and Applications (LESA) ERC, where he was Education Director. He was RPI ECSE Department Head from 2001 to 2008 and served on the board of the ECE Department Heads Association (ECEDHA) from 2003 to 2008. He is a Life Fellow of the IEEE.

Prof. Ibibia K. Dabipi, University of Maryland, Eastern Shore

I. K. Dabipi has been in academia for approximately 26 years during which he worked for Bellcore, AT&T Bell Labs and Southern University. He was the Chair of the Electrical Engineering Department at Southern University from 1997 to 2001. He was Professor and Chair of the Engineering and Aviation Science Department at University of Maryland Eastern Shore from 2001 - 2006. He is currently a Professor in the Department of Engineering and Aviation Sciences at University of Maryland Eastern Shore.His research interests are in the areas of Computer Security and Network Management, Parallel Computing and Algorithms Development, Performance Evaluation of Computer Networks, Optimization of Transportation Networks, and Economic Analysis of Transportation Facilities and Human factors in Aviation Security. He is a member of ASEE, HKN, ACM and a senior member of IEEE

Dr. Abdelnasser A Eldek, Jackson State University

Dr. Abdelnasser A. Eldek obtained his Ph.D. in Electrical Engineering in 2004 from the University of Mississippi. Currently, he is Associate Professor with the Department of Electrical and Computer Engineering at Jackson State University. His main research areas include Applied Electromagnetics, Antennas, Phased Arrays, RF/Microwave Circuits, Metamaterial, Numerical Methods, and Engineering Education.

Dr. Demetris Geddis, Hampton University

Demetris L. Geddis is an associate professor and Chair of Electrical and Computer Engineering at Hampton University. He has extensive research experience in the areas of Integrated optoelectronics, Optics, Microelectronics, and Electromagnetics. He has worked as a Research and Design Engineer at Motorola and Bell laboratories. Also, he worked at NASA Langley Research Center as a NASA faculty fellow for the Nondestructive Evaluation Sciences Branch where he performed research in the area of optical fiber sensing for real time health monitoring of aerospace vehicles. In addition, Prof. Geddis was a Research Engineer at the Georgia Tech Research Institute where he fabricated scalable multiplexed ion traps for quantum computing applications. Current research interests and publications are in the areas of Photonics, Optoelectronics, Microelectronics, Heterogeneous thin film integration, single-fiber bi-directional communications, optical sensing, and ring lasers.

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Dr. Petronella James-Okeke serves as the Accreditation Coordinator for the School of Engineering, at Morgan State University (MSU), where she leads the 2019 multi-program accreditation process. Dr. James-Okeke previously served as the Assessments and Online Program, Faculty coordinator for the Department of Electrical and Computer Engineering. She teaches at the graduate and undergraduate level, using both face-to-face and blended online learning instruction. She is an Adjunct Faculty for the Transportation Systems and, the City & Regional Planning programs at MSU.

Her research interests include engineering education, student success, online engineering pedagogy and program assessment solutions, transportation planning, transportation impact on quality of life issues, bicycle access, and ethics in engineering. She has several published works in engineering education and online learning. Dr. Petronella James earned her Doctor of Engineering (Transportation) and Masters of City & Regional Planning at Morgan State University (MSU), Baltimore, Maryland. She completed a B.S. Management Studies, at the University of the West Indies (Mona), Jamaica.

Dr. John Carey Kelly Jr., North Carolina A&T State University

Dr. John C. Kelly, Jr. is an associate professor in the Department of Electrical and Computer Engineering at North Carolina A&T State University. He received his Ph.D. in Electrical Engineering from the University of Delaware. Dr. Kelly's research interests include hardware security in cyber-physical systems and embedded systems security. He also contributes to research on engineering education, enhanced retention of underrepresented minorities in engineering, and hands-on learning techniques.

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Dr. Juan C. Morales, P.E., joined the Mechanical Engineering Department at Universidad del Turabo (UT), Gurabo, Puerto Rico, in 1995 and currently holds the rank of professor. Dr. Morales was the ABET Coordinator of the School of Engineering for the initial ABET-EAC accreditation of all four accredited programs at UT. He has been Department Head of Mechanical Engineering since 2003. His efforts to diffuse innovative teaching and learning practices derive directly from the outcomes assessment plan that he helped devise and implement as ABET Coordinator.

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Mandoye Ndoye received the B.S.E.E. degree from the Rensselear Polytechnic Institute, Troy, NY, in 2002, the MS degree in Mathematics and the Ph.D. degree in electrical and computer engineering from Purdue University, West Lafayette, IN, in 2010. After completing his Ph.D. studies, he joined the Center of Applied Scientific Computing, Lawrence Livermore National Laboratory, as a Research Staff Member. From 2012 to 2014, he was a Research Associate at Howard University. Since 2014, he has been an Assistant Professor with the Department of Electrical Engineering, Tuskegee University, Tuskegee, AL. His research interests center on signal/image processing, sensor data analytics, intelligent infrastructure systems and power systems optimization.

Dr. Kofi Nyarko, Morgan State University

Dr. Kofi Nyarko is a Tenured Associate Professor in the Department of Electrical and Computer Engineering at Morgan State University. He also serves as Director of the Engineering Visualization Research Laboratory (EVRL). Under his direction, EVRL has acquired and conducted research, in excess of $12M, funded from the Department of Defense, Department of Energy, Army Research Laboratory, NASA and Department of Homeland Security along with other funding from Purdue University's Visual Analytics for Command, Control, and Interoperability Environments (VACCINE), a DHS Center of Excellence. Dr. Nyarko has also worked as an independent Software Engineer with contracts involving computational engineering, scientific/engineering simulation & visualization, visual analytics, complex computer algorithm development, computer network theory, machine learning, mobile software development, and avionic system software development.

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Dr. Stella A Quinones, University of Texas, El Paso

Dr. Stella Quinones is chair of the Metallurgical, Materials and Biomedical Engineering department at UTEP with more than 20 years experience in academia. Her multidisciplinary engineering background includes; Design, Testing and Analysis of sensors for Biomedical Applications such as Non-Invasive Glucose Sensing; 3D Printing Machine Development; Engineering Education; Characterization of High Strain Rate Materials for Space Applications; and Fabrication and Characterization of CdTe and Si for X-ray Imaging and Solar Cell Applications. Engineering Education research includes efforts to increase the number of engineering degrees awarded to women by creating an inclusive, enriching, and engaging environment in the classroom. Dr. Quinones has been recognized for outstanding teaching efforts including the UT Regents' Outstanding Teaching Award, nominated for US Professor of the Year, Frontiers of Engineering Education Early-Career Engineering Faculty, and the UTEP Distinguished Achievement Award for Teaching Excellence.

Dr. Michel A Reece, Morgan State University

Michel A. Reece is currently serves as the Interim Chairperson within the Department of Electrical and Computer Engineering at Morgan State University. She is also the director of the Advanced RF Microwave, Measurement and Electronic Design Laboratory (ARMMED). In this lab, she pursues research in the areas of high frequency device characterization and modeling, highly efficient solid-state power amplifier design, and adaptable components design for software defined radio applications. She became the first female recipient at Morgan State to obtain her doctorate degree in engineering in 2003. She received her B.S.E.E from Morgan State in 1995 and her M.S from Penn State in 1997, both in electrical engineering. She has worked at companies such as Northrop Grumman, Johns Hopkins University Applied Physics Lab, and Boeing (formerly known as Hughes Aircraft Company). She has a passion for education where she has taught as an adjunct faculty member at Johns Hopkins University and participated as a volunteer tutor to middle and high school students within her local community.

Dr. Lei Zhang, University of Maryland, Eastern Shore

Dr. Lei Zhang received his Ph.D. Degree in Electrical Engineering on 2011 from the University of Nevada, Las Vegas. Since 2012 he is working in the Department of Engineering and Aviation Sciences, University of Maryland Eastern Shore. His main research interests include image processing, autonomous system, optical SoC/NoC architecture, and on-chip optoelectronic device design.

Dr. Saleh Zein-Sabatto, Tennessee State University

Saleh Zein-Sabatto: Dr. Zein-Sabatto has a strong commitment for teaching and research. His area of competency includes teaching and conducting theoretical and experimental research in intelligent control systems, adaptive control systems, manipulator controls, intelligent mobile robotic behaviors, cooperative multiple robotic systems, fault diagnostics systems, neural network and fuzzy logic applications to robotics and control. Dr. Zein-Sabatto has been teaching engineering design for over fifteen years.

I. Introduction

For more than five years, a consortium of 13 Universities has been collectively implementing experimental centric pedagogy (ECP) in their ECE circuits and electronics courses. Howard University, Morgan State University, Alabama A&M University, Florida A&M University, Hampton University, Jackson State University, Norfolk State University, North Carolina A&T State University, Prairie View A&M University, Southern University, Tennessee State University, Tuskegee University, and University of Maryland Eastern Shore, received funding for a National Science Foundation (NSF) grant entitled, *"Experimental Centric Based Engineering Curriculum for HBCUs"* to create a sustainable "HBCU Engineering Network" that is focused on the development, implementation, and expansion of an Experimental Centric-based instructional pedagogy in engineering curricula used in these HBCUs. The goal of the project was to increase the number of highly qualified and prepared African American engineers and to have a better understanding of technology and its role in STEM education and the policy associated with it. Another key goal for the project was to promote wide spread dissemination of portable hands-on mobile devices through proactive collaboration between educational institutions and industry partners. Collaborating partners used portable hands-on hardware coupled with a model of pedagogy to provide instruction in their courses. The project successfully demonstrated that an experimental centric pedagogy combined with hands-on educational technology stimulates student interest in the STEM area, promotes content acquisition, problem solving, and retention. Hands-on activities were shown to be successful across a variety of instructional settings and introductory EE topics. [1,2,3,4,5]

Evidence of the Effectiveness of the ECP Approach

The thirteen Universities with Electrical Engineering programs had more than 40 faculty now trained in ECP and mobile hands-on learning; by the end of year three, these faculty had introduced experimental problem solving and the Digilent Analog Discover Board (ADB) to over 1400 students; 83% of these students represent ethnic minorities with approximately 73% self-representing as Black. [4]

More than half of student participants (59%) identified Electrical Engineering (EE) as their major discipline of study. A smaller portion of students reported Computer Science (13%) or Mechanical Engineering (8%) as areas of study with EE coursework serving as an elective or minor. Year of study or degree progress varied by institution, but across the project, per term, approximately one fourth of the students were in their first year of engineering education (usually an introductory class), one fourth were in their 2nd year (usually a circuits class), one third were in their 3rd year of study (usually a second circuits class or a non-major introductory circuits class), with approximately 17% in a 4th year advanced content or practicum class; year 4 students also represented some non-EE majors enrolled in elective study.

Evaluator site-visits verified that all 13 HBCUs were actively integrating experimental, hands-on learning into classes. The use of ECP/ADB occurred in multiple settings and in different ways with preliminary evidence that different types of use had an impact on level of outcomes. Settings included traditional classroom/lecture courses (as demonstration and in blending real world problem solving), laboratory classes (stand-alone and integrated), and as homework. Individual sites varied in mode and site of implementation, but overall, there was a growing use of immersing the lab sessions within a traditional classroom lecture setting.

Observations, interviews with faculty and students, and a review of curricula revealed major use of the pedagogy in circuits related courses. Methods of implementation included use in labs, integration into theory/concept courses, in-class supervised work, and independent homework. When queried, a notable 84% of the students enrolled in circuits classes reported that the use of the ADB helped them to learn more (See **Table 1**). Subsequent follow-up questions as to how the process of use helped to support these immediate learning outcomes received high agreement scores.

Table 1: How Methods of Implementation Supported Learning Outcomes

	Areas of Growth	**%***
General Outcome	Helped me to learn more	84
Immediate Learning	Develop skills in problem solving in the content area.	78
Immediate Learning	Think about problems in graphical/pictorial or practical	75
Immediate Learning	Learn how AC and DC circuits are used in practical	74
Immediate Learning	Recall course content.	73
Immediate Learning	Improve grades	70
Pre-requisite to	Develop confidence in content area	75
Pre-requisite to	Become motivated to learn course content.	71
Pre-requisite to	Develop interest in the content area.	69
Pre-requisite to	Confidently complete lab assignments.	69

*Number represents percentage of participants who responded "Strongly Agree"/"Agree" on post-survey; n=267

Actions related to affective pre-requisites include helping students to develop interest (69%), to become motivated to learn content (71%), to become confident in learning course content (75%) and more specifically to become confident in completing lab assignments (69%). Specific areas of learning noted included recalling course content (70%), learning about practical applications of AC/DC circuits (74%), thinking about problems in graphical/pictorial/practical ways (75%), and developing skills in problem solving within the content area (78%). These skills were reported by the students as helping to directly improve their grade.

Evaluating the Need for Continued Collaboration

As a step toward growing and sustaining a successful collaboration of programs developing and implementing experimental centric pedagogy, a deeper understanding of the nature of the

collaboration between the ECP institutions was studied to address such questions as why it has been successful, how can it be improved, how it can be expanded and adopted by others and how it can be sustained. [6]

For example, one key finding from this study was:

> *"Multiple outcomes related to collaboration were cited including learning about greater opportunities for funding, the value/power of a joint network, a greater understanding of common needs, shared goals in designing and developing new classroom techniques, and methods related to meeting common student services. Faculty noted that this network was worthy of continuation and they wanted support for collaborating on course improvements, maintaining the network, and searching for shared funding."*

Because of the project's success, participants expressed continued interest in collaborating on research and in shared dissemination of information; this includes working together on gaining support for research, conference work, and sharing advanced opportunities for students. Another outcome of this collaboration was a definite willingness to increase their participation in the project and a desire to extend invitations to others to become involved. Expansion within their local sites and outreach to satellite and local community colleges were cited frequently as potential areas of growth.

A workshop to allow the group to further refine a way forward was conducted. Regular conference calls and a project involving a next generation AI development tool was also implemented. In this paper the results of these group efforts will be presented as well as an update on the status of the targeted areas of collaboration.

II. Methodology

The approach to implementing the workshop was to first invite and mentor new partners and then form working groups to create white papers on four areas of mutual interest.

Prior to the Workshop

In the month before the workshop, new members were asked to identify their motivation for participation in the ECP group and review representative examples from ECP courses and then go through a general introduction to personal instrumentation and ECP by reading past publications. New members were added if they had both prior interactions with group members and ABET-accredited Engineering or Engineering technology programs with minority-serving status.

The four collaborative areas were determined by consensus and found to be: the formation of a new ECE Diversity Organization; pursuing support for combined research experiences for undergraduates and research experiences for teachers REU-RET involving all partner institutions

in the collaboration; pursuing a research collaboration as a major center; and pursuing an enhanced extension of ECP with simulation and programming.

At least one week before the workshop each group was expected to complete the following:

- Identify a leader, a scribe and team members (from a pool of ECP participants, from new partners, from industry and from NSF)
- Conduct a literature survey in each area
- Update a topic Statement and summary of work to date
- Post materials to others working in the group so that they can read materials before workshop and post questions/comments

Tasks Completed at the Workshop

Upon arriving at the workshop, a template was given to each group to: refine the literature survey; prepare a summary of the present status, a SWOT for the topic; defining the goals moving forward, identifying the barriers or major tasks to be completed; Identifying the relationship to previous work; determining what infrastructure and resources are required; compose statements on intellectual merit and broader impact; and develop a task list/time line for the project.

III. Results

The workshop took place over one and a half days in Alexandria, Virginia. Details about the schedule of activities during each day of the workshop are presented in **Table 2: Workshop Agenda** as shown below.

Table 2: Workshop Agenda

Collaborative Area Topic #1 Formation of a new ECE Diversity Organization

While the original 13 partners have been working to solidify and sustain the impact of ECP on improving the learning experiences of their students, the newly augmented group has been developing new technical research collaborations: a leadership working group has been

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UMI Workshop
June 18-20, 2018

Monday, June 18ᵗʰ
6:00 pm   Welcome Reception & Dinner
                               The Alexandrian Hotel

Tuesday, June 19ᵗʰ
7:30 am   Breakfast
8:00 am   Welcome and Introduction
8:05 am   Introduction of Potential New Partners
8:15 am   Overview of Status of the Project
8:30 am   Q&A
10:15 am   Morning Break
10:30 am   Session – Mega/REU/RET
12:00 pm   Working Lunch
1:30 pm   Session – ERC
3:00 pm   Afternoon Break
3:15 pm   Session – Intel
6:00 pm   Dinner

Wednesday, June 20ᵗʰ
7:30 am   Breakfast
8:00 am   Day 1 Recap
8:15 am   Q&A
8:30 am   Session – open ended
11:30 am   Departures

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exploring how to realize the most effective working infrastructure for the evolving Minority-Serving Institutions (MSI) consortium. By identifying the primary barriers to future success, it has become clear that a new support organization is necessary if collaborations (like ECP) of *historically minority* serving institutions are to work together as one. With the assistance of Electrical and Computer Engineering Department Heads Association (ECEDHA), the group has created such a new organization called the *Inclusive Engineering Consortium (IEC).* The

consortium consists of a core group of collaborators roughly equal in size to the present augmented group and a second, much larger group of affiliated members from other universities, industry and professional societies.

There are other organizations like the Inclusive Engineering Consortium with similar goals to increase the pool of minority engineering workforce candidates. For example, there is the Advancing Minorities' Interest in Engineering (AMIE) organization, which leverages partnerships with industry and government organizations to provide resources to the HBCU engineering schools. Secondly, there is the 50K Coalition, a group of minority-serving professional engineering societies which is focused on achieving a national goal to produce 50,000 diverse engineering graduates by the year 2025. The 50K coalition is comprised of the American Indian Science & Engineering Society (AISES), the National Society of Black Engineers (NSBE), the Society of Hispanic Professional Engineers (SHPE) and the Society of Women Engineers (SWE). Each organization within the 50K coalition addresses the individual needs of each group. Finally, there is the National Action Council for Minorities in Engineering (NACME) which was created at nearly the same time as the American Society for Engineering Education (ASEE) Black Engineering College Development program.

The aforementioned organizations share common goals of increasing the pool of minorities though leveraging partnerships between industry, government, academia, and existing engineering societies such as American Association of Engineering Societies (AAES) and the American Society for Engineering Education (ASEE). The uniqueness of this coalition, the IEC, is that it transcends the typical partnerships and allows the constituents to perform as an Electrical and Computer Engineering "super department" that unifies the individual programs with broadly based strengths in education, scholarship and service.

The key finding for this collaborative is that the group should further develop a formal structure in the form of a 501(c)(3) non-profit organization. ECEDHA should play a role in allowing the group access to a broader set of Electrical and computer engineering resources during the early stages of development.

Collaborative Area Topic #2: Research Experiences for Undergraduates and Research Experiences for Teachers Mega Site

The goals going forward for the research experiences for undergraduates (REU) and research experiences for teachers (RET) mega site were stated as: 1) Agree on combined or separate REU/RET; 2) Agree on an associated research project/proposal (Smart and Connected Cities); 3) Determine which institutions will be host sites; 4) Determine if the proposal will include AP material; 5) Establish ongoing meeting times; and 6) Get feedback from NSF on submission date.

A SWOT analysis for the simulation and programming extension collaborative topic is shown in **Table** .

Table 3: SWOT Analysis for the Research Experiences for Undergraduate and Research Experiences for Teachers Mega Site Topic

STRENGTHS	WEAKNESSES
- We have a large number of participants to draw on - Each institution knows their community (we have access to feeder schools) - Existing proposal - Students will have a wide variety of research opportunities available - Good record of student mentorship - Teachers would help recruitment (Marketing) - Because it's a large consortium, students will get to see all parts of a related topic	- Managing a large number of participants - Strengths(talents) are distributed among a large number of institutions - We haven't identified the projects that will be a part of the proposal (identify host institutions, and research thrusts) - We need to be able to identify "low performing" students - Students may not be interested (recruitment) - We don't have experience with REU/RET on this scale - Teaching loads
OPPORTUNITIES	THREATS
- Provide a model incorporating a large number of low performing students in research - Provide content for AP courses in engineering for teachers - Teacher professional development through the local school board - Being able to recruit into graduate programs at host sites	- Being able to work with the school systems (need approval from local school board) - More competition with other opportunities - Lack of administrative support

The SWOT analysis informs the construction of the intellectual merit and the broader impact statements. The Key findings from these statements are:

The first component of this project will be the implementation of a REU program that will provide a rich research experience and professional development opportunities to a large population of under-served minority students enrolled in the 13+ engineering programs and their partner community colleges that have been unable to participate in traditional summer resident research programs. It builds on the strength of an existing 13+ institution Engineering consortium. The REU/RET Megasite will be built around the Smart and Connected City research theme, which will encompass the following research strengths in the host sites: Cyber Security, Power/Energy (renewable), Autonomous Systems, and Materials. We also envision the RET teachers to return to their respective schools and community colleges not only with some

technical background in research, but also with new content they can incorporate in their course materials, [therefore playing a vital role in preparing students to pursue education in a STEM field. If we succeed to place at least 20% or 15 out of the 84 REU participants in PhD programs at the end of five years, we will be on track to increase the number of African American students obtaining a PhD in engineering in the nation by 10%, or by 50% if we focus on Electrical Engineering, based on the graduation numbers obtained for the year 2009.

The broader impact of this project will have two different components. First, providing quality research experience to an underserved group of undergraduate students in the 13+ universities and community colleges will lay the foundation for a significant impact not only on the retention and graduation of engineering students for years to come but also on the number of minority students who will eventually pursue graduate work. Secondly, since typical REU or RET sites are located at one university (ERC programs are an exception), this one of a kind REU/RET Megasite can serve as a national model for a successful implementation of future multi-institution undergraduate research programs.

Collaborative Area Topic #3: Major Collaborative Research Center

The goals going forward for the major collaborative research center were stated as: 1)Seek out a funding opportunity to pursue within the next 6 months, 2) Continue with bi-weekly meetings to refine ideas. 3) Identify existing similar research groups internal and external to the ECP group.

A SWOT analysis for the major collaborative research center collaborative topic is shown in **Table** .

Table 4: SWOT Analysis for the Major Collaborative Research Center Topic

STRENGTHS	WEAKNESSES
- Pre-existing Network of 13+ HBCUs - Have experience in technology-based education enhancement research - Concept is transportable - Research will include a diverse population of faculty and students - We are the market for the technology that we want to develop - Our solution may fill a gap (focus on diverse students) that industry will not focus on	- Lack of connection with educational expertise - Research focus is not broad enough - Disagreement about whether or not we should include engineering educational research as a component of the research - May not have the infrastructure to carry out the research - Partnership includes only HBCUs - May not have the infrastructure to carry out the research -

OPPORTUNITIES	THREATS
- All participating universities have education departments to leverage - No current ERCs dedicated to Educational technology development - Opportunity to implement pilot tests at other institutions - Industry is not interested in develop such technology to specifically target Minority students - Advanced personalized learning is a fertile research field (NAE Grand Challenge) - Pervasive/Ubiquitous computing is a fertile field	- Our proposal may be interpreted by NSF as an engineering education proposal - Rapidly changing technology - Industry may invest large amount of resources and develop the ideas - A major university my pick up on the idea and advance it faster

The SWOT analysis informs the construction of the intellectual merit and the broader impact statements. The Key findings from these statements for the major collaborative research center collaborative topic are:

The overarching research question the Center will address is "How can smart and connected technology be used to design systems that assist with the task of learning in a personalized and efficient way?" The research methodology that will be undertaken within the proposed Center to address this question will be to design, implement, and evaluate pervasive (i.e., smart and connected) computing-based educational enhancement systems that are: (1) aware of, and responsive to, characteristics of the user and its physical environment, (2) aware of, and responsive to, the system's local and remote educational information and resources which are dynamic in nature, and (3) designed with a user-centered approach, where the primary users are university students, many of which will be at minority serving institutions (MSI).

Beyond the classroom, the proposed research will benefit society at-large by providing people with tools that support their learning experience anywhere and anytime. The commercialization of such personalized education enhancement technology may be useful for enhancing on-the-job learning and training for workers in industrial, academic, and government jobs. Also, the developed technology out of the center could have a positive impact on workforce productivity, and thus the economy on the whole.

Collaborative Area Topic #4: Simulation and Programming Extension to ECP (ECP+)

The goals going forward for the simulation and programming extension were stated as: 1) Get and incorporate feedback from all other faculty members of the HBCU ECP consortium. 2) Update the workshop proposal to incorporate the inputs that were provided during the Underserved Minority Institutions (UMI) workshop discussions and the feedbacks from the ECP colleagues. 3) Submit the workshop proposal to NSF.

A SWOT analysis for the simulation and programming extension collaborative topic is shown in **Table** .

Table 5: SWOT Analysis for the Simulation and Programming Extension Topic

STRENGTHS	WEAKNESSES
- Experience and success of the HBCU ECP consortium in implementing experiential learning/pedagogy projects - Highly motivated faculty that are eager to implement the experiential learning ideas at HSI, HBCUs - Most of the needed resources are already available - Prior experience in ECP for all team members. - Track record of results and publications in the area. - Diversity of faculty involved - Transformative initiative that can have great impact in retention/graduation rates at HSIs and HBCUs - Availability of a previous exhaustive assessment	- Lack of extensive experience in the associated educational learning models. - Faculty buy-ins to implement the needed curriculum changes - High faculty teaching loads at HSIs and HBCUs - There is not enough involvement from junior faculty: Large time commitment seems to be a deterrent
OPPORTUNITIES	THREATS
- There is great interest and enthusiasm in STEM education and workforce development - Potential to greatly improve retention, especially first-year retention - Graduation of well-rounded, more qualified engineers	- Lack of human and financial resources - Not enough faculty to implement the initiative - Lots of others institutions that can easily implement the project

The SWOT analysis informs the construction of the intellectual merit and the broader impact statements. The Key findings from these statements are:

The proposed enhancement to the pedagogy - (ECP+), will provide additional pathways to acquire deeper technical skills. These pathways to acquire even deeper technical skills should

make the student more broad-minded in proffering solutions to technical problems. For example, the addition of simulation as another alternative path to examining a technical problem will help the students to broaden their technical skills. Similarly, having the students examine the same or similar technical problems through programming, likewise helps them expand, even more so, their critical thinking, technical, software and problem-solving skills.

IV.   Summary and Conclusions

To date, this process has yielded a fully chartered 501(c)(3) non-profit organization and a successfully funded REU-RET Mega-Site: Research Experiences for Undergraduates and Teachers in Smart and Connected Cities. The collaboration between the now 16 institutions within the ECP community will have a positive long-term impact on the development of new cooperative efforts in technical research, engineering education research and curriculum development for minority-serving institutions and is expected to have a significant impact on the retention and graduation of engineering students.

V.   References

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