

Nomination to R1 Commission - Cover Page

Title of Area: Research and Education for Broadening Participation in Computing

Participating Disciplines/Academic Units/Departments:

College of Computing and Informatics

- Department of Software and information Systems
- Department of Computer Science
- Center for Education Innovation

Cato College of Education

- Department of Educational Leadership
- Center for STEM Education
- Reading and Elementary Education

College of Liberal Arts & Sciences

- Department of Sociology
- Organizational Science

Three Individuals Responsible for Leading the Research Area:

Dr. Mary Lou Maher, Professor, Director of Center for Education Innovation

Dr. Tonya Frevert, Research Assistant Professor, Software & Information Systems

Dr. Harini Ramaprasad, Teaching Professor, Computer Science

Target Category:

Existing and Emerging Excellence

Keywords:

computing education

engaged pedagogy, learning, and technology

diversity, equity, & inclusion

K-12 teacher preparation and partnerships

STEM workforce development

Executive Summary

As computing permeates every aspect of our society, the need for a robust and diverse STEM workforce to support our global economy is both a national and regional imperative. This R1 research proposal strongly positions UNC Charlotte to be a national and regional leader on Research and Education for Broadening Participation in Computing. Spanning three UNCC Colleges (CCI, COED, and CLAS), the over 25 members who comprise this research team draw on their Existing and Emerging Excellence to bring together an interdisciplinary team of colleagues who will advance our commitment to research and education for broadening participation in computing through collaborative and convergent research. We build upon existing collaborations at UNCC among computer science, education, sociology, organizational science, and psychology to achieve sustainable, systemic change in computing.

Broadening participation in computing seeks to democratize computing education and to develop theories, best practices, and models that enable the participation and success of under-represented groups in our tech-enabled society and the current/future workforce. Advancements in information technology have made globalization a worldwide phenomenon; innovation and excellence in mathematics and sciences are critical for a nation's economic prosperity, safety, and quality of life [1]. This proposed research area of R1 Existing and Emerging Excellence aims to transform K-20 computing education at all levels--student, faculty/teacher, and organization--to create more equitable and inclusive learning experiences that diversify and strengthen the STEM workforce. Embedded in its Strategic Plan, NSF's commitment to broadening participation aims to prepare a diverse, globally engaged STEM workforce while integrating research with education [2]. Over \$30 million in grants related to computing education have been awarded among this research team, demonstrating our ability to receive national and regional funds in pursuit of these research endeavors. Additionally, this research team has successfully published over 200 papers in the past 5 years, many of which represent joint collaboration amongst the team. With over 60 doctoral students advised and trained, the talents of this team will be propagated to other institutions through the research pipeline. Support and recognition of Research and Education for Broadening Participation in Computing as one of UNC Charlotte's R1 areas will foster and sustain excellence in this area.

Led by three faculty members from the College of Computing and Informatics with complementary expertise and experience, this proposed R1 research area has the potential to position UNC Charlotte as a national and regional leader for broadening participation in computing. As previously stated, computing permeates every aspect of our society. This research team sees the future potential for eventually including faculty members from all Colleges at UNC Charlotte, for computing and technology also touch the disciplines of business, engineering, health, arts and architecture. By supporting and recognizing Research and Education for Broadening Participation in Computing as an R1 research area, we can help UNC Charlotte achieve its mission "to address the cultural, economic, educational, environmental, health, and social needs of the greater Charlotte region" [3] and beyond.

Evidence of Strength and Excellence

The three co-leads from the College of Computing and Informatics (CCI) bring together the complementary expertise and experience needed to lead and foster excellence in research and practice within this area. Dr. Maher (Professor, Director of the Center for Education Innovation and the Integrated Critical Core) has extensive experience in leading large educational grants and directing educational initiatives. Dr. Frevert (Research Assistant Professor) brings research expertise in diversity, equity and intersectionality in computing education from a sociological and organizational science perspective. Dr. Ramaprasad (Teaching Professor and Director of Undergraduate Programs) brings expertise in the development, practice and evaluation of inclusive and engaged pedagogy. The strength of the team of contributing faculty members is evidenced by their research grants (totaling over \$30M), publications (totaling over 200 within the past 5 years, including several joint publications), over 60 doctoral students advised and trained, engagement with the community, their diversity across disciplines, and their distinct, but interrelated research areas. Mary Lou Maher, one of the leads for this nomination is in the top 2% of the world for the number of citations [4]:

The recent grants related to computing education demonstrate the ability for this area to receive external national and regional funds from a broad range of sources:

- IUUSE/PFE:RED: *The Connected Learner: Design Patterns for Transforming Computing and Informatics Education* (NSF \$2.2M): Maher, Rogelberg, Frevert, Rorrer
- S-STEM: *Improving the Persistence and Success of Students from Underrepresented Populations in Computer Science* (NSF \$1M): Dorodchi, Mickelson, Pugalee
- CS4ALL: *Broadening Participation with the STEM Ecosystem: Developing a Scalable Model for CS using an RPP approach* (NSF \$500K): Maher, Cao, Rorrer, Pugalee, Dorodchi
- SaTC:EDU: *Enhancing Security Education in Hybrid Mobile and Internet of Things Firmware through Inclusive, Engaging, Learning Modules - E-SHIELD* (NSF \$444K): Ramaprasad, Bahamón
- EHR: *Interactive Learning Analytics Framework* based on a Student Sequence Model for understanding students, retention, and time to graduation (NSF \$300K): Maher, Dou, Dorodchi
- CompCog: RI: Small: *Pique: A cognitive model of curiosity* for personalizing sequences of learning resources (NSF \$450K): Maher, Najjar
- Capacity Building: Collaborative Research: *Integrated Learning Environment for Cyber Security of Smart Grid* (NSF \$215K): Wang
- Gambrell Faculty Fellowship, *A games approach to increase interest and participation in cybersecurity careers* among middle-school students who come from underrepresented communities. (UNCC Urban Institute \$15,000): Bahamón
- Atkins Library and the College of Arts + Architecture *Gaming for All: Increasing Diversity and Inclusion in Video Games* (Chancellor's Diversity Challenge \$4,000): Bahamón
- IC-CRIME (<https://liquidnarrative.eae.utah.edu/ic-crime/>) focusses on the use of game-based environments to help Crime Scene Investigators be more effective and to improve their collaboration (NSF awarded to Utah \$1.4M): Bahamón

- Award for Inclusion Research Program: *Understanding How Peer and Near Peer Mentors co-Facilitating the Active Learning Process of Introductory Data Structures Within an Immersive Summer Experience Effected Rising Sophomore Computer Science Student Persistence and Preparedness for Careers in Silicon Valley* (Google \$60K): Mejias
- Scholarship of Teaching and Learning: *Learning Together While Staying Apart: Scaffolding Active Collaborative Learning for Student Success in Online Courses* (UNCC \$11K): Ramaprasad, Bates, Byker, Furr-Rogers, Van Doren
- Computer Science Research and Underrepresented Support, *exploreCSR* (Google Research \$17K): Wilson, Mejias.

The institutional, regional and national impact of this research is highlighted by the Centers and events initiated in this area.

- The Center for Education Innovation (CEI), directed by Dr. Maher, was established in 2013 and has coordinated over 20 externally funded projects that transform and diversify computing and informatics education. The CEI ensures the broader impact of this research through faculty development and a community of practice for CCI faculty in teaching and pedagogical research. The CEI instituted ACE-IT! (Advancing Computing Education) in Summer 2020, an initiative to facilitate wide adoption of inclusive, engaging pedagogical practices and establish a faculty community of practice that attracted 29 CCI faculty (including over 10 faculty on this team).
- The Center for STEM Education in the Cato College of Education (COED) was established over 30 years ago and is currently directed by Dr. Pugalee. This Center promotes the effective teaching and learning of STEM PK-20+ and supports university and grant-funded initiatives around STEM programming, teacher professional development, STEM education leadership development, STEM student research programs, and STEM enrichment programs.
- The Active Learning Academy (ALA), organized by the Center for Teaching and Learning (CTL) at UNCC, provides faculty with research and professional development opportunities focused on education. While this is not an initiative of the faculty in this nomination, many of our faculty are members of the ALA and have received collaborative Scholarship of Teaching and Learning (SoTL) grants.
- The STARS Computing Corps was launched in 2006 in CCI and grew to a national organization of over 50 universities. STARS students engage in life changing community service leadership programs, attend an annual Celebration, and enroll in service leadership courses. Originally funded by NSF for \$15M over 10 years, the STARS students are now supported by a \$750K Duke Energy scholarship program.
- The Integrated Critical Core (ICC) was established in 2019 in the College of Computing and Informatics to coordinate and enhance the learning and experience of students in the first two years of the BA/BS in Computer Science with innovative, adaptive learning pedagogy.
- Several team members participate as Faculty Pioneers within the Student Experience Project (SEP), a multi-institution project funded by the Raikes Foundation. The SEP aims to find tools and practices that will broadly impact student success and lower the equity gaps in gateway STEM courses. Faculty Pioneers play an important role in implementing and evaluating interventions to help close those equity gaps.

Alignment with Regional and National Priorities

“Computing permeates every aspect of our society, creating a high demand for technological innovations that change how we think, connect, conduct research, build products, and more. This demand drives the economy and creates a direct impact on the job market; by 2028, the Department of Labor estimates 4 million computing-related job openings in the US, but only 19% of these jobs that could be filled by US computing bachelor’s degree recipients. Computing underpins every other STEM discipline as a skillset that is essential in today’s information economy” [5]. However, diversity in computing is lacking. “Even though computing jobs offer some of the highest salaries available, we’re failing to make computing education accessible to all and attract and retain diverse talent to the discipline” [5].

Nationally, “the need for a robust and diverse STEM workforce has been reiterated for decades, and it is one of the current administration’s top priorities in order to maintain America’s historical preeminence in the STEM fields” [6]. NSF is committed to broadening STEM participation and aims to prepare a diverse, globally engaged STEM workforce while integrating research with education. This proposed R1 research area addresses two of *NSF’s 10 Big Ideas: the Future of Work* and *NSF INCLUDES*¹ [7]. As demand for a diverse tech workforce surpasses the current/projected labor supply [8], it is critical that research and education in computing addresses the challenges and opportunities at the human-technology frontier. To catalyze the STEM enterprise for inclusive change at a national scale, K-20 computing education must be transformed collaboratively to foster “a STEM workforce that reflects the population of the nation” [9].

Despite major increases in US collegiate computing enrollments in recent years, computing degree attainment remains largely unchanged [10]. The degree gap for women and students of color remains static and wide, with just 22% of computing degrees awarded to women and 17% awarded to African American, Latinx, and Native American students. At the K-12 level, the lack of neither a national nor many state computing curriculums leaves US students unevenly exposed to computing and thus not equally prepared to pursue technology education or careers after finishing high school. This “digital divide” is exacerbated for students of color and/or students of high poverty [11]. Further compounding the issue, 48% of K-12 schools lack teachers who have the necessary preparation and training in computing [12].

Regionally, UNCC serves over 2.5 million people across the Charlotte metro area of the NC/SC bistate. The Charlotte area’s economic and employment outlook is strengthened by the region’s rise as a “hub” in the energy and technology sectors [13]. However, Charlotte was identified as having the worst economic mobility among the 50 largest cities in the US, making the climb out of poverty more difficult here than any other major metro area in the country [14, 15]. In response, UNCC’s Civic Action Plan charges our community to address these systemic inequalities [16]. The members of this proposed R1 research area are already deeply engaged via robust research, funding, and engaged teaching practices that align with these national and regional priorities. This level of engagement strongly positions UNCC to be a national and regional leader on research and education for broadening participation in computing.

¹ In January 2021, members Maher, Ramaprasad, Frevert, Rogelberg, and Rogelberg submitted a \$10 million NSF INCLUDES proposal in partnership with Temple University and North Carolina State University.

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Participating Members, Titles, and Academic Units

Name	Title	Department/Unit
Dewan Ahmed	Associate Teaching Professor	Computer Science
Julio C. Bahamón	Associate Chair - Academics & Teaching Assistant Professor	Computer Science
Debarati Basu	Assistant Teaching Professor	Software & Information Systems
Lijuan Cao	Teaching Associate Professor	Software & Information Systems
Mohsen Dorodchi	Teaching Professor	Computer Science
Wenwen Dou	Assistant Professor	Computer Science
Kathleen Dunn	Program Coordinator	Center for Education Innovation
Liyue Fan	Assistant Professor	Computer Science
Atif Farid Mohammad	Adjunct Associate Professor	Computer Science
Tonya Frevert	Research Assistant Professor & Associate Director Center for Education Innovation	Software & Information Systems, Center for Education Innovation
Heather Lipford	Interim Associate Dean for Research and Professor	Software & Information Systems
Mary Lou Maher	Professor, Director Center for Education Innovation, Director of Integrated Critical Core	Software & Information Systems, Center for Education Innovation
Marlon Mejias	Assistant Teaching Professor	Software & Information Systems
Roslyn Arlin Mickelson	Chancellor's Professor	Sociology, Public Policy, and Women's and Gender Studies
Nadia A. Najjar	Teaching Assistant Professor	Software & Information Systems
Xiaoxia Newton	Associate Professor	Educational Leadership
Manuel A. Pérez-Quiñones	Professor	Software & Information Systems
David Pugalee	Professor & Director Center for STEM Education	Center for STEM Education
Harini Ramaprasad	Teaching Professor & Director of Undergraduate Programs	Computer Science
Sandy Rogelberg	Research Assistant Professor	Reading & Elementary Education
Steven Rogelberg	Chancellor's Professor	Organizational Science, Psychology, & Management
Audrey Rorrer	Research Associate Professor	Computer Science

Erik Saule	Associate Professor	Computer Science
Weichao Wang	Chair and Professor	Software & Information Systems
Dale-Marie Wilson	Teaching Associate Professor	Software & Information Systems
Yonghong Yan	Associate Professor	Computer Science
Jing Yang	Professor	Computer Science