



Enhancing Research Infrastructure and Workforce Diversity in Higher Education Through Strategic Collaboration and Investment

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ABSTRACT

Many smaller and under-resourced institutions, including MSIs, HSIs, HBCUs, and EPSCoR institutions, are engaged in significant science research and education and recognize the value of enhanced access to advanced computing resources. Collaborations, shared resources, and expertise from local, regional, and national levels can substantially support their internal efforts. The Ecosystem for Research Networking (ERN) Broadening the Reach (BTR) working group is actively learning from these institutions on how to better support their needs. The group's findings and recommendations, derived from community engagement, will be shared, as part of the NSF-sponsored CC*CRIA grant OAC-2018927.

CCS CONCEPTS

- General and reference → Cross-computing tools and techniques;
- Social and professional topics → Computing profession; Computing education.

KEYWORDS

Research Computing, Research Instruments, Workforce Development

ACM Reference Format:

Forough Ghahramani, Sunita Kramer, James Barr von Oehsen, Maureen Dougherty, and John Hicks. 2024. Enhancing Research Infrastructure and Workforce Diversity in Higher Education Through Strategic Collaboration and Investment. In *Practice and Experience in Advanced Research Computing (PEARC '24), July 21–25, 2024, Providence, RI, USA*. ACM, New York, NY, USA, 4 pages. <https://doi.org/10.1145/3626203.3670583>

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PEARC '24, July 21–25, 2024, Providence, RI, USA

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<https://doi.org/10.1145/3626203.3670583>

1 INTRODUCTION

Research competitiveness is strongly correlated to access to advanced cyberinfrastructure (CI) [1], research instruments, and resources. Historical Cyberinfrastructure (CI) underinvestment at small to medium sized institutions, including MSI's, has created degrees of unevenness in the national distribution and availability of CI resources, impacting competitiveness. To address the gaps, it has been suggested that the CI ecosystem in the United States will require increasing coordination, collaboration, and planning across multiple federal, state, institutional, and public/private boundaries for efficient, effective, and equitable access [2]; our findings, and in a broad sense, those of the ERN Broadening the Reach (BTR) working group concur with that suggestion. In addition, urgent workforce challenges exist, particularly in terms of underrepresentation from key communities, including people of color, women, persons with disabilities, and first-generation scholars. In order for the research computing community to address the most urgent scientific and societal challenges of the 21st century, the advanced CI workforce must embody a wide range of skills and perspectives, fully reflecting the diversity of society, including traditionally underrepresented communities. “The Missing Millions” report [3] highlights the need for racial, ethnic, and gender representation equity in technology.

The role of research computing and data in scientific discovery and scholarship across all disciplines presents challenges as well as opportunities. The Ecosystem for Research and Networking (ERN) [4] was formed as a consortium of institutions and regional network providers that agree to simplify and enable multi-campus research collaborations and partnerships between academic institutions of all types and sizes that advance the frontiers of research, pedagogy, and innovation. The ERN adheres to the principles that promote team science and simplifies access to both instruments and data, and supports democratizing research data and instruments with a particular emphasis on broadening the reach to under-resourced and under-represented colleges and universities. The ERN includes the Broadening the Reach (BTR), Architecture and Federation, Policies, Structural Biology, and Materials Discovery Working Groups.

Gaining a better understanding of the advanced computing and resource requirements, and outreach to best support researchers, educators, and upper administration from the public and private colleges and universities of all shapes and sizes is essential. The

majority of these institutions are small to medium sized non-R1 colleges and universities, including MSIs, HSIs, and HBCUs. The ERN BTR working group is representative of the diverseness of these communities and focuses on how the ERN can be more inclusive, and through a deeper understanding to enable the ERN to have the broadest impact across multiple research disciplines, pedagogical approaches, university and college stakeholders, and organizations within the region and beyond.

The ERN BTR working group was established to address the lack of data characterizing the computational infrastructure (CI) capabilities and needs of under-resourced institutions, to enhance access to regional and national resources, and build a skilled, diverse workforce to support advanced CI. This group has taken a multi-pronged approach to understand and support the specific needs of small to medium-sized institutions. The discussions and workshops conducted by the ERN BTR have pinpointed key obstacles in CI development for these institutions, such as access to funding, expertise, training, mission perception, leadership awareness of research technology, prioritization of resources, lack of policy, and underdeveloped communication channels. These challenges have led to tailored recommendations for funding agencies and institutions to enhance CI development and collaboration for research and education.

ERN activities have reached hundreds of participants from academia, industry, and government, fostering knowledge-sharing and collaboration. Additionally, the ERN's Data Science Seminar Series offers practical training in machine learning and artificial intelligence (AI) to researchers and research computing professionals from various backgrounds, promoting workforce development. An important aspect of the outcome of ERN efforts includes the community of like-minded thought leaders that has been formed. The ERN community is actively forming partnerships and engaging with organizations such as the Consortium of Liberal Arts Colleges (CLAC), Research Computing for Small Institutions (RCSI), and aligning efforts with the Minority Serving – Cyberinfrastructure Consortium (MS-CC)[5] to foster initiatives and drive innovation.

As an outcome of discussions with these communities, the April 2024 ERN Summit, held at the Pittsburgh Supercomputing Center in Pittsburgh, PA, brought together small and/or under-resourced institutions, including MSI's, HBCU's, and TCU's to discuss challenges and opportunities in their respective institutions, and to highlight existing research collaborations, funding opportunities, and innovative workforce development programs. The Summit also featured innovative use of technology to broaden the reach and impact of research instruments and resources, emphasizing collaborative efforts, accessibility, and the advancement of research capabilities through state-of-the-art platforms and initiatives. The Summit provided opportunities for open discussion and conversations on focused topics and policies as they pertain to areas of community interest including AI, quantum, Big Data, cybersecurity and protecting data, research instruments, workforce development, applications for ERN, education, and training. The summit included two workshops: (1) a thought leader strategy session that resulted in recommendations and collaboration opportunities between R1's and non-R1's, and (2) a workshop aimed to educate participants on the deployment and utilization of cloudlets for facilitating remote access to Cryo-Electron Microscopy (CryoEM) instruments.

A diverse set of stakeholders, including domain researchers, research computing professionals, network and system administrators, campus Deans, CIOs and other administrators, and regional network leaders participated in the Summit. The Summit attracted 60 participants from more than 45 distinct organizations. Most attendees were from academic institutions, including 10 R1's and 23 non-R1's (includes small liberal arts schools, HBCU, MSI, TCU). Other organization types represented were consortiums, The National Science Foundation (NSF), industry participants, and regional/national networks. The next three sections of this paper will share results of the Summit, including findings, recommendations, and ERN BTR future plans.

2 FINDINGS

The primary goals for the Summit included fostering mutual learning, discussing the democratization of access to research instruments, updating attendees on the ERN Working Groups' activities, and exploring future projects and collaborations. Emphasis was also placed on workforce development, the role of funding agencies, and envisioning a national federated ecosystem for research and education. Non-R1 institutions, including small, liberal arts colleges, MSIs, and HBCUs face several distinct challenges in advancing their research capabilities and leveraging advanced computing technologies.

- **Student Involvement:** The absence of graduate students limits research support and the development of interdisciplinary collaboration and knowledge transfer.
- **Expertise Scarcity:** Difficulty in attracting and retaining specialized expertise due to funding limitations, geographic isolation, and competition with larger institutions hinders progress in advanced computing and emerging technologies.
- **Resource Constraints:** Limited resources often make it challenging to address specialized research initiatives effectively, leading to potential inefficiencies and compromised project outcomes.
- **Tool Utilization:** The effective use of new research tools and technologies is often impeded by a lack of awareness and expertise among faculty, impacting the institution's ability to tackle complex research questions.
- **Geographic Isolation:** Many smaller institutions are located in rural or underserved areas, which restricts access to advanced computing infrastructure and collaborative opportunities, limiting their competitive edge in securing research grants.
- **Cultural Barriers:** Internal cultural resistance to collaboration and hierarchical structures may prevent the development of a collaborative research environment.
- **Workload Constraints:** Heavy teaching loads and administrative duties reduce faculty availability for research activities and external collaboration, impacting research productivity.
- **Lack of Professional Services:** There is often a shortage of professional services such as grant writing and research management, which are crucial for securing funding and managing research effectively.

- **Data Management Challenges:** Effective management of research data is compromised by inadequate infrastructure and the lack of standardized data management practices, affecting research integrity and collaboration.
- **Limited Collaboration Opportunities:** Opportunities for collaborations between research intensive R1 researchers and those from non-R1 institutions are limited. Summit participants representing non-R1 institutions, including smaller colleges and particularly those from MSIs, HBCUs, and TCUs, raised concerns about often being involved in research projects primarily for broader impacts and for contributing Letters of Commitment/Support. They emphasized the desire to be integral, core contributors to collaborative proposals, rather than being included superficially as "5th PIs" merely to fulfill diversity requirements for broader impacts.
- **Resource Sharing:** The lack of democratized access to remote research instrumentation at the institution/lab level hinders collaboration and grant opportunities particularly for smaller, under resources colleges.

The Summit highlighted the complex challenges and opportunities that research universities, non-R1 and smaller institutions face in research support and technology use. Key issues include resource management, expertise availability, and clear policies. Technological innovations and collaborative efforts are improving research capabilities and setting new standards for infrastructure development. Strategies like collaboration, capacity building, and strategic initiatives are essential to share and optimize resources, share expertise, and foster innovation. Additionally, educational programs and inclusive practices are crucial to prepare for advancements in AI and quantum technology. The NSF promotes participation in research panels and emphasizes community networks to enhance capabilities and create inclusive research environments.

The findings underscore the importance of collaboration, capacity building, and strategic initiatives in addressing the complex challenges faced by research universities and smaller institutions. Just as networked systems achieve outcomes that surpass their individual capabilities, institutions, particularly smaller ones, also realize greater benefits when they collaborate and form networks. By embracing these strategies, stakeholders can foster a culture of innovation, drive interdisciplinary collaboration, and ultimately advance knowledge and discovery within the higher education landscape.

3 RECOMMENDATIONS

Based on the Summit, targeted suggestions and recommendations have been developed for individual institutions, the ERN, and Funding agencies:

Targeted Suggestions for Funding Agencies

- (1) **Invest in Capacity Building:** Allocate funding for capacity-building initiatives aimed at enhancing research support, advanced computing capabilities, research instrumentation,

and interdisciplinary collaboration within smaller institutions. Support training programs, workshops, and professional development opportunities to empower faculty members and researchers with the skills and knowledge needed to leverage advanced computing technologies effectively.

- (2) **Promote Collaborative Partnerships:** Encourage collaborative partnerships and consortia among institutions by providing grant opportunities that incentivize resource sharing, infrastructure development, and interdisciplinary research initiatives. Support initiatives that facilitate networking and collaboration among research institutions of varying sizes and specialties to promote knowledge exchange and innovation.
- (3) **Facilitate Access to Resources:** Provide funding and resources to establish centralized repositories, shared facilities, and research networks and the supporting connective tissue or methodology that enables smaller institutions to access advanced computing and research instrumentation infrastructure, specialized equipment, and research support services. Foster collaboration between funding agencies, industry partners, and academic institutions to enhance resource accessibility and promote research excellence.
- (4) **Funding for Educational Programs:** Increase funding for programs that expand STEM education, particularly in underserved communities, to prepare a diverse workforce capable of leading future innovations.

Recommendations for Small/Non-R1 Institutions

- (1) **Strengthen Institutional Capacity:** Invest in building institutional capacity by prioritizing professional development, training, and mentorship programs for faculty members, researchers, and staff. Leverage external funding opportunities (e.g. NSF CC*, MRI, SCIE), and collaborative partnerships to enhance expertise, infrastructure, and research support services within the institution.
- (2) **Foster Collaboration:** Cultivate a culture of collaboration and knowledge sharing among faculty members, researchers, and students by establishing interdisciplinary research teams, joint projects, and community engagement initiatives. Explore opportunities for collaboration with other institutions, industry partners, and government agencies to leverage resources and expertise.
- (3) **Promote Grant Writing and Management:** Provide support and resources for grant writing, management, and compliance to streamline the funding acquisition process and maximize external funding opportunities. Establish dedicated offices or personnel to assist faculty members with grant proposal development, budgeting, and reporting requirements.

Recommendations for R1 Universities

- (1) **Support Small Institutions:** Extend support and resources to smaller institutions through collaborative partnerships, joint research initiatives, and capacity-building programs. Offer mentorship, training, and technical assistance to help smaller institutions enhance their research capabilities and leverage advanced computing technologies effectively.

- (2) **Facilitate Resource Sharing:** Establish mechanisms for resource sharing, collaboration, and knowledge exchange among research universities and smaller institutions. Promote initiatives that facilitate access to shared facilities, research networks, and specialized expertise to foster innovation and interdisciplinary research collaboration.
- (3) **Promote Diversity and Inclusion:** Prioritize diversity, equity, and inclusion initiatives within research universities by fostering a welcoming and inclusive environment for faculty members, researchers, and students from diverse backgrounds. Promote collaboration with minority-serving institutions, HBCUs, and under-resourced institutions (e.g., the Princeton University PACRE program) to promote diversity in research and innovation.

Recommendations for the ERN

- (1) **Expand Networking Opportunities:** Facilitate networking opportunities, collaborative forums, and knowledge-sharing platforms to connect researchers, institutions, funding agencies, and industry partners within the research ecosystem. Promote interdisciplinary collaboration, resource sharing, and best practices across diverse domains and specialties.
- (2) **Support Interoperability and Integration:** Promote interoperability, integration, and sharing of research instruments, networking tools, platforms, and services to streamline collaboration, data sharing, and communication within the research community. Foster the development of standardized protocols, data formats, and interoperable systems to facilitate seamless integration and information exchange. This would encompass the connective tissue necessary to support the democratized infrastructure for sharing and remotely accessing research instruments across science domains at the institution level with the potential to partner these resources into a network of resources available to the broader research community.
- (3) **Advocate for Policy and Funding Support:** Advocate for policy initiatives and funding support that prioritize research networking, infrastructure development, and collaborative research initiatives. Engage with policymakers, funding agencies, and industry stakeholders to highlight the importance of investing in research networking infrastructure and fostering

4 OPPORTUNITIES AHEAD

The knowledge gained from the Summit and other ERN community engagement efforts are used by the ERN to develop strategies and prioritize initiatives to support the needs of the research community while fostering collaboration and partnerships among

diverse sets of institutions. Education, Community, Collaboration, and Resource Sharing initiatives are at the heart of ERN activities, including the ERN federated infrastructure architecture design developing the connective tissue for democratized resource sharing, building the next generation workforce to support important areas such as cloud adoption, and designing workshops and webinars to raise awareness to existing resources and to gain further insights from the community. The ERN community is excited about leveraging the learnings and best practices identified to make advanced computing resources, including instruments more widely available to researchers and educators.

ERN future plans related to Broadening the Reach and workforce development includes identifying sources of funding to focus activities on three important thrusts: (1) Foster a supportive and inclusive culture in research and research computing communities that promote collaborations; (2) Identify sustainable pathways through internship and workforce development programs for students from underrepresented groups (and faculty working with them), to collaborate with staff at R1 institutions on world-class R&D projects in specific areas such as Quantum and AI; and (3) Create an Intro to ACI immersive program designed to engage students in research activities using project-based pedagogy and real-life science stories to teach foundational skills in HPC, scalable AI, and analytics while exposing students to the excitement of mission-driven team science.

ACKNOWLEDGMENTS

The co-authors thank the ERN Working Group members for workshop program development and execution, the ERN Steering Committee for guidance and support, and the Pittsburgh Supercomputing Center and Carnegie Mellon University staff for event management support. The workshop was funded by the NSF CC* CRIA grant (OAC-2018927).

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