Emerging Needs for Advanced Cyberinfrastructure at Under Resourced Institutions: Findings from a National Workshop on Expanding Computing Using Collaborative Models

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ABSTRACT

Despite the fact that advanced cyberinfrastructure (CI) resources are now essential for all research and education domains, there is a large disparity in CI resources and engagement between large, research-focused (R1) universities and under-resourced 2- or 4- year institutions. The Building Research Innovations in Community Colleges (BRICCs) community was established to foster communication and collaboration between CI administrators and providers, researchers, and educational professionals across all levels to address inequities in CI accessibility and research. To that end, BRICCs held its second annual workshop in August 2022 with the goal of identifying common hurdles, limitations, and bottlenecks faced by under-resourced institutions and establishing a set of guidelines and recommendations to ameliorate them. This report contains the findings of the 2022 BRICCs workshop and will serve as a valuable resource for CI administrators, educators, and academic researchers.

CCS CONCEPTS

• **Cyberinfrastructure Accessibility**; • **Community College Resources**; • **Funding Cyberinfrastructure**;

KEYWORDS

Cyberinfrastructure, 2-year institutions, workforce development

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1 INTRODUCTION

The dominant role of data-enabled science and engineering practices in industry and research workflows places cyberinfrastructure (CI) at the heart of developing academic programs. Community colleges and under-resourced 4-year schools, while focused on instructional delivery, are now strategically expanding their instructional capacity and programs around computing. Some are trying to build data science programs and have even acquired cutting-edge campus clusters. As these institutions incorporate CI in their academic and research programs, they face shared challenges that are related to their region, size, or expectations set forth by their mission statement. Common to them all, is the lack of CI-facilitating support for students and faculty. Several of these challenges can be overcome through coordinated and collaborative efforts. The community needs a platform where institutions can collectively pool and share knowledge as they integrate CI in their academic and business missions [1]. It is essential that this platform be designed with the needs of under-resourced institutions and two-year colleges in mind. Building Research Innovations at Community Colleges (BRICCs) [2] is a community-building effort that is actively exploring ways to address these adoption challenges at these institutions. Among its primary goals, BRICCs endeavors to increase access to and awareness of advanced cyberinfrastructure within this community with the understanding that CI engagement and utilization at smaller institutions with a regional focus will differ from how these resources are accounted for and utilized at larger R1 universities. BRICCs has organized a series of community workshops to identify pathways to help smaller 2–4-year institutions incorporate research CI [3]. The goal is to articulate the needs of these institutions, and the differences and similarities between their mission, funding culture, and business processes and those of large research intensive (R1) universities. To this end, BRICCs hosted the workshop "Collaborative Computing Models" to understand the opportunities, challenges, and strengths of advancing CI at these institutions by adopting collaborative approaches toward regional computing. The workshop builds on the first BRICCs "Landscape" workshop that focused on presenting research, CI, and teaching resources, curricula, and case studies for and from smaller colleges [3].

2 METHODOLOGY

This report summarizes findings from the second workshop to collaborate and learn what smaller universities and community colleges are doing now and what they can be doing in the future in terms of incorporating CI-enabled research into their curriculum. The Collaborative Computing Models workshop was held from August 11-12, 2022, at Texas A&M University Corpus Christi (TAMU-CC), an R2 university that is the recipient of a 2022 CC* [2, 4] computing award for regional computing. The body of this report outlines the findings of the workshop and complements our paper that reports recommendations resulting from the workshop [5]. Most of the 65 workshop participants attended the workshop in person, and represented the perspectives of senior administrators (Deans, Vice Presidents for Research, Chief Information Officers), junior and senior researchers, students, and computing professionals at community colleges, two-year and small four-year universities. Participants also represented Research and Education Networks (RENs), R1 universities and large computing centers, industry, and the NSF Office of Advanced Cyberinfrastructure (OAC) Directorate [6]. The workshop benefited from an active working committee that built on the recommendations of the Landscape workshop [3]. One of the important findings from the Landscape workshop was to recognize that smaller, regional, and R1 institutions have different CI needs. A key construct was to identify how one can build regional collaborations around this. The workshop consisted of a clearly defined program of panels and provided large time allotments for open post-panel discussions, sharing of personal experiences at their institutions, Q&A, and social-networking time to facilitate collaborations. The participants represented over 30 different institutions across 14 states. The topics covered in the workshop helped illustrate the need for advanced CI at diverse types of academic institutions. Thematic areas included (i) describing the landscape for regional computing models; (ii) understanding how advanced cyberinfrastructure (ACI) be used to support the academic mission of an institution; (iii) exploring mechanisms to situate CI to accelerate research at smaller schools; (iv) understanding student perspectives on the need for CI; and (v) identifying best-practices for regional collaboration that have been used by RENs and regional centers. Each of the topics was discussed from the perspectives of the diverse workshop participants. Panels were punctuated with a presentation on the future of large-scale computing and an invigorating open-ended discussion on computing in a research enterprise. Insights gained from this workshop and outlined in this report provide value both to smaller institutions seeking to find models to support their needs for computing resources and expertise for teaching and research projects and to larger R1 institutions and regional organizations seeking to understand the ways in which they could support these institutions.

3 FINDINGS AND OBSERVATIONS ON MAJOR CHALLENGES TO ADVANCING CI ADOPTION

Community colleges and smaller 4-year institutions have different operating models, missions, and academic programs than large R1 universities. Mechanisms to establish CI resources and training at these institutions can therefore not take the same approach as larger institutions where financial return on investment (ROI) on expanding and maintaining CI has been demonstrated. We note that community colleges and smaller 4-year institutions differ in their academic mission but face similar underlying challenges to CI adoption [7]. At community colleges research is typically not a primary mission. Skill-based education is the core goal in these settings. Rather than solely focusing CI to advance research, identifying means whereby investments in CI can simultaneously expand the education priorities while advancing research are needed. CI literacy varies widely across communities and setting. It is important to recognize that knowledge is often less than ideal in terms of people understanding the roles technology plays in supporting research and education, how core technologies are used and managed in academic environments, and the rapidity with which CI technologies are advancing. Models of CI support in the 2- and

4- year space must be reimagined as we consider some of these restraints and challenges.

One challenge is the relationship between IT support and researchers. Often tools that can benefit research institutions are restricted by IT regulations that need to be addressed at the policy and personnel levels. Researchers are often reluctant to adhere to regulations or see regulatory compliance regarding CI resources as an overhead that can impede research. There is a perceived lack of awareness among higher-level administrators about the need for CI and trained CI support at their universities. The needs for research CI must be clearly communicated by faculty and CI proponents in a way that resonates with the goals of administrators and helps them understand why CI adoption should be considered a priority. Furthermore, there is a general lack of awareness about what CI resources are available; both at the local, regional, and national levels. Another common roadblock is the aging and/or low-capacity nature of existing infrastructure in some institutions. In some places, this is the result of continued underinvestment in these resources. Many also have a lack of basic connectivity (e.g., small institutions, outlying facilities, rural areas). Many of these institutions also do not have identification and authentication procedures that will allow deployment of federated CI access. Lastly, there are some differences in cultural understanding when it comes to the role of CI and digital data. Understanding these perspectives and requirements is necessary to establish CI that meets the needs of all users. Combined, these are perceived as insurmountable blocks.

3.1 Lack of Trained Personnel

People are the hardest of all variables required to develop a proficient CI ecosystem. Supporting grand endeavors is not possible without finding a community of purpose in CI. One of the biggest challenges is the lack of technical staff to manage CI resources - smaller institutions do not have staff dedicated to this like larger R1 universities. Many institutions lack sufficient personnel for maintenance of existing CI and, as a result, the staff that is present does not have the bandwidth or training for new technologies. These types of positions allow for staff to focus on enabling research. We find that the "people" and expertise parts of computing delivery are an extremely important aspect. Several hurdles prevent acquiring and retaining necessary CI personnel. If the appropriate support and training positions are created, these CI positions are staffed with highly skilled individuals who are adept at switching between technology practices and research focus, and, as a result, they are in short supply. These staffing issues are exacerbated by the increasing need for multidisciplinary approaches in modern research. Mechanisms to support students enrolled in computational programs are becoming more critical as research, leading to further demand for people. The apparent lack of preparatory or certification mechanisms to prepare CI professionals is another issue. The CI micro-credential program at Texas A&M and classes by Internet2 are a means for training [8, 9]. Finally, smaller 2–4-year institutions don't have dedicated career-paths or resources to support CIPs. The salaries offered are often not competitive enough to recruit the required personnel; and CIPs need communities to contribute and learn from.

3.2 Situating CI Adjacent to the Academic Mission to Accelerate Research

Salaries offered at these institutions are often not competitive enough to recruit the required CI-trained faculty. A second concern is curricular and programmatic development around CI resources; and, finally, access to the CI resources themselves. Aligning the CI needs with an institution's existing academic and business operational models is, however, not an easy process. Faculty and instructors at under-resourced institutions are diverse in their needs for and utilization of CI resources. It is not uncommon for faculty at smaller or 2-year institutions to have come from larger R1 universities and have experience working with HPC resources or CI backgrounds. The limited CI infrastructure and support at their current position may not allow them to bring to bear their full knowledge or skill sets for teaching students. Some areas of research and teaching would benefit greatly from access to internal large-scale computing resources, but the number of researchers or faculty requesting these resources might be limited and may not be able to reach the critical mass at a single institution with a new Data Science or CI-enabled program. It is important to identify all the areas of research or teaching that could utilize these resources to justify their acquisition and maintenance by an institution.

4 OPPORTUNITIES FOR GROWTH

4.1 Effectiveness of lead institutions in assisting with research at 2-4-year schools

The efficacy with which R1 universities engage with 2–4-year institutions varies considerably across regions. For the purposes of this discussion, we look beyond the articulation agreements between schools. Many mature R1 universities have developed well established relationships with smaller institutions and provide regular inclusion in grants, outreach, technology resources, and CI training and education. Larger universities are consolidating services to achieve economies of scale, expand CI services, and build accessible infrastructure with appropriate security protocols. Smaller institutions are not in a position to do this and run the risk of falling behind unless they get help. In some instances, there are well established and fruitful relationships between flagship institutions and smaller schools, whereas other R1 universities might still be struggling with internal CI issues or are working on implementing CI strategies to cope with institutional growth and shifts in technologies, culture, and ecosystems. This latter issue is especially prevalent in emerging R1s and can inhibit their ability to help or impact regional 2–4-year institutions. It is important to acknowledge that science and engineering research at BRICCs institutions is tightly coupled with teaching and educational processes. This inherently results in differences in the scope, expectations, and complexity of research at 2–4-year colleges relative to larger R1 universities that are driven by research priorities. Developing combined curricular products around CI that benefits from existing articulation agreements could help strengthen these relationships. These relationships will likely benefit by introducing mechanisms that incentivize more "research-curious" 2–4-year schools, by helping them adopt CI technologies.

4.2 Students Need CI in Academics and to Pursue Careers in Technology Fields

Cyberinfrastructure has become pervasive within academic and industry sectors as research computing and data, advanced networking, cloud services (public and private), and cybersecurity are now a necessity in order to be competitive in this technology and data driven world. This dependency on cyberinfrastructure requires a skilled workforce, trained in the current state-of-the-art, that is able to anticipate and exploit future technologies and solutions [10]. These skills are of interest to both academia and industry. Community colleges, by design, are geared to support industries, often those local or in a region. As such, the educational needs of the students are heavily influenced by local industry, which in turn affects the CI tools and resources available. Developing strategies that involve collaboration between smaller institutions and R1s and leverage the relationships between smaller institutions and industry partners could result in opportunities for CI deployment and training that are unique to these schools and include a combination of hands-on experience, coursework, and research guided by both academia and industry. Schools with limited access to CI, not only limit a student's academic and career prospects, but may also cause students to get frustrated and move away from CI-enabled work and research as a whole. Students are often not fully aware of an organization's CI resources, lack an understanding of what CI is and can provide, and can be too intimidated by CI to feel comfortable getting started. This causes the under-utilization of CI by students during their academic career. Nationally, we note that few students from smaller 2–4-year schools have accounts at national CI centers, and there is a need for faculty to buy in for support. Having faculty act as mediators between students and CI resources could help establish a point-person for students to reach out to for help or other information.

4.3 Lessons learned from RENs and regional centers in taking a collaborative approach

One reassuring development is that RENs are now working to fill needs at 2–4-year schools that are not part of their traditional role and charter. They have worked through technology and adoption roadblocks via community engagement and organizing, providing access or information to research resources or services, acting as coordinators or leaders for funding proposals, piloting new technologies, spanning boundaries between administrators, researchers, and IT personnel, and acting as a bridge between national and regional communities and entities. RENs have relationships with institutions of all sizes covering the gamut from research oriented R1s to community colleges. The key drivers in these relationships are not interactions with academics and researchers, but largely with institutional leadership and CIOs. These relationships have helped facilitate inter-institutional collaborations at several states.

5 DISCUSSION

Community colleges and smaller 4-year institutions serve students with a wider skill and experience base and thus have a larger and more flexible goal outcome. This can be leveraged as we identify collaborative mechanisms to holistically incorporate CI in their curricular and research programs [10]. A common roadblock identified in establishing CI at under-resourced institutions is a lack of technical personnel and expertise needed to maintain these resources. Attracting qualified faculty and staff can be a major problem with budget limitations even at larger universities, and this problem is exacerbated at institutions with more restrictive means. There are opportunities for larger, resource-rich institutions to actively seek and invite people from smaller institutions to participate in training opportunities. Developing strategies that rely on collaborations and pooled resources could help offset disparities between institutions. These pooled resources could not only include hardware and personnel, but also training and educational opportunities. Lastly, facilitating cross-institutional collaborations and understanding the differences in the scope and expectations of research between smaller institutions and larger universities is key to addressing the disparities in CI accessibility.

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REFERENCES

[1] Edmundo Medina-Gurrola, Dhruva K. Chakravorty, Diana V. Dugas, Tim Cockerill, Lisa M. Perez, Emily Hunt. (2022). Regional Collaborations Supporting Cyberinfrastructure-Enabled Research During a Pandemic: The Structure and Support Plan of the SWEETER CyberTeam. In *Practice and Experience in Advanced Research Computing (PEARC '22)*, 4 pages. https://doi.org/10.1145/3491418.3535186

[2] NSF BRICCs, Retrieved June 15, 2023 from https://www.nsf.gov/awardsearch/showAward?AWD_ID$=$2019136

[3] Dhruva K. Chakravorty, Sarah K. Janes, James V. Howell, Lisa M. Perez, Amy Schultz, Marie Goldie, Austin L. Gamble, Rajiv Malkan, Honggao Liu, Daniel Mireles, Yuanqi Jing, Zhenhua He, Tim Cockerill. (2022). Expanding the Reach of Research Computing: A Landscape Study: Pathways Bringing Research Computing to Smaller Universities and Community Colleges. In *Practice and Experience in Advanced Research Computing (PEARC '22)*, 4 pages. https://doi.org/10.1145/3491418.3535169

[4] Campus Cyberinfrastructure (CC*), Retrieved June 15, 2023 from https://beta.nsf.gov/funding/opportunities/campus-cyberinfrastructure-cc

[5] Dhruva K. Chakravorty, Sarah K. Janes, Wesley A. Brashear, Sharon Broude Geva, Scotty Strachan, Forough Ghahramani, James V. Howell, Ralph Zottola, Lisa M. Perez, Honggao Liu, Amy Schultz, and Tim M. Cockerill. 2023. Improving Access to Advanced Cyberinfrastructure Using Regional Computing Collaborations and People Networks: Recommendations from a National Workshop on Expanding Computing Using Collaborative Models. In *Practice and Experience in Advanced Research Computing (PEARC '23)*, Portland, OR, USA. ACM, New York, NY, USA, 6 pages.

[6] NSF Office of Advanced Cyberinfrastructure (OAC) Directorate, Retrieved on June 15, 2023 from https://www.nsf.gov/div/index.jsp?div$=$OAC

[7] Dhruva K. Chakravorty, Sarah K. Janes, James V. Howell, Lisa M. Perez, Amy Schultz, Marie Goldie, Austin L. Gamble, Rajiv Malkan, Honggao Liu, Daniel Mireles, Yuanqi Jing, Zhenhua He, Tim Cockerill. (2022). Expanding the Reach of Research Computing: A Landscape Study: Pathways Bringing Research Computing to Smaller Universities and Community Colleges. In *Practice and Experience in Advanced Research Computing (PEARC '22)*, 4 pages. https://doi.org/10.1145/

3491418.3535169

[8] Dhruva K. Chakravorty, Andrew J Palughi, Ritika Mendjoge, Richard E. Lawrence, Lisa M. Perez, Marinus Pennings, Zhenhua He, Xin Yang, Randy McDonald, Wesley Brashear, Jacob Pavelka, Gerry Pedraza, Sunay V. Palsole, Honggao Liu. 2022. Access to Computing Education Using Micro-Credentials for Cyberinfrastructure. Ninth SC Workshop on Best Practices for HPC Training and Education (BPHTE22), The International Conference for High Performance Computing, Networking, Storage, and Analysis (SC22), Nov 13-18, 2022, Dallas, Texas.

[9] Research Engagement - Internet2. Retrieved June 15, 2023 from https://internet2.edu/community/research-engagement/

[10] Edmundo Medina-Gurrola, Dhruva K. Chakravorty, Diana V. Dugas, Tim Cockerill, Lisa M. Perez, Emily Hunt. (2022). Regional Collaborations Supporting Cyberinfrastructure-Enabled Research During a Pandemic: The Structure and Support Plan of the SWEETER CyberTeam. In *Practice and Experience in Advanced Research Computing (PEARC '22)*, 4 pages. https://doi.org/10.1145/3491418.3535186