BRICCs: Building Pathways to Research Cyberinfrastructure at Under-Resourced Institutions

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ABSTRACT

Dramatic growth in the use of computing in educational practices and research workflows encourages two-year institutions to adopt large-scale computing practices rapidly. Advanced cyberinfrastructure (CI) resources are required to support educators, students, and researchers in cloud computing, data sciences, and related cross-cutting fields such as smart manufacturing. While community colleges will differ in enrollment, geographical location, business models, and programs offered, the underlying institutional needs to store, access, manage, analyze, compute, and curate their data remain the same. Working with regional efforts to advance computing and networking, we discuss collaborative models to develop appropriate adoption models with them.

CCS CONCEPTS

• **Human-centered computing** → **Collaborative and social computing**; • **Social and professional topics** → **Professional topics**; • **Applied computing** → *Education*.

KEYWORDS

cyberinfrastructure, community college academic resources, cyberinfrastructure accessibility

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1 INTRODUCTION

Insights from computing have transformed work, education, scientific inquiry, industrial practice, economies, and how we live. Building Research Innovations at Community Colleges (BRICCs) [10] is a National Science Foundation CC* CIRA project that aims to improve the state of cyberinfrastructure (CI)-enabled research and education practices at two-year institutions of higher education (IHE). Two-year institutions, commonly referred to as community colleges or junior colleges, play an outsized role in preparing our nation's workforce. With strong connections to industry, community colleges have proven to be fertile ground for future entrepreneurs. Research at community colleges largely focuses on advancing practical applications. It is employed to improve technologies and the educational experience in skill-based programs, as seen in NSF Advanced Technological Education (ATE) [12] awards. Today, these institutions are charged with preparing students in technology services, semiconductor chip manufacturing, cybersecurity, advanced manufacturing, data sciences, cloud computing, and healthcare. However, a series of continuously evolving challenges in adopting CI need to be addressed. Research programs in STEAM (Science, Technology, Engineering, Art, and Mathematics) have demonstrably benefited from the rapid growth of computational capacity and the extensive use of data analytics tools. Preparatory programs in

these fields rely on access to CI and knowledge of trends in research practices. Most institutions have limited or no campus CI to support growing data science and computing-enabled programs. They are willing but find themselves largely unprepared to incorporate advanced CI into their educational practices. They have limited pathways to learn about research practices that inform industry standards in these fields.

A common question remains: "What is the nature of research at two-year institutions?" To highlight the research efforts at such institutions, we present case studies from select programs at two community colleges. San Jacinto Community College (SJC) is a two-year institution embracing student internships and research. It is preparing for a generation of college students who are making the economic choice by starting their education at a two-year institution but are otherwise university-ready. With that, a different caliber of students has presented itself in these settings. Undergraduate research has really become a reality. SJC is actively exploring creating a sustainable research program that's institutionalized and won't disappear with the faculty member that has largely driven the experience. In this environment, certifications and industry-partnered internship programs offer a means to expand a student's horizon. Indeed, eighteen SJC students worked alongside Intuitive Machines engineers and research scientists to build the Odysseus rover. At Houston Community College (HCC), the Cyber Security program is nationally recognized by the National Security Agency (NSA) as a Center of Academic Excellence in Cyber Defense (CAE-CD) [11]. The Cyber Security program includes a Security Operations Center (SOC) for live training. HCC also offers an associate in applied science (AAS) in Artificial Intelligence (AI), which has garnered curricular and technical support through HCC's partnerships with Intel, Microsoft, and Amazon. HCC also offers a Bachelor of Applied Technology in Artificial Intelligence & Robotics that covers the latest information and real-world experience. SJC and HCC are partnering with the Texas Advanced Computing Center (TACC) and Texas A&M High Performance Research Computing (HPRC) to ensure their researchers and students can access cutting-edge CI resources.

Much like SJC and HCC, forward-thinking community colleges recognize that their technical / skills-based training programs offer opportunities to incorporate research computing practices. In their quest to be equal partners in preparing a CI-trained workforce, they enthusiastically partner with industry and research-intensive four-year institutional programs to develop programs offering students research experiences. They are looking for a platform that provides a pathway to bringing advanced CI and CI-enabled research to their campuses. Perhaps not surprisingly, these considerations rise to under-resourced 4-year universities that also aspire to grow their research programs. In many ways, they face similar challenges and opportunities in this space.

There is a growing divide between established research-intensive (R1) universities, nascent research institutions (R4), and under-resourced, four-year universities and community colleges. The BRICCs mission, to make CI accessible for researchers everywhere, is critical. BRICCs unites groups motivated to develop a framework to support CI-enabled education and research at these institutions. BRICCs seeks to bridge the gap in access to CI resources between these institutions along these guiding principles: 1) meaningful conversations with non-R1 schools about the state of research on campus and the needs of the research community, 2) the formulation of practical ways of interaction between R1, non-R1 and national cyberinfrastructure institutions such as ACCESS, 3) serving as facilitators of CI research at community colleges by raising awareness of training and professional development opportunities, and 4) provide guidance for community college faculty and staff on NSF proposal submissions, especially concerning the NSF CC* program. To this end, BRICCs brings together leaders from various institutions nationwide, including community colleges, small and large universities, and Research and Education Networks (RENs), to foster communication and collaboration between researchers and administrators at these different institutions. At the heart of this collaborative effort is the need to understand what a meaningful programmatic model means to regional computing that supports under-resourced four- or two-year institutions. This collaboration is unique and scales to bring different CI communities to embrace the concept that providing regional solutions is a likely path to seeding transformative national impact on several fields of science and engineering that use CI.

2 METHODS AND PREVIOUS WORK

BRICCs engage the community through two primary mechanisms and by several other ancillary means. The primary engagement mechanisms are annual in-person workshops and weekly (virtual) calls. BRICCs met with institutional Chief Information Officers (CIOs), faculty, students, and academic leadership to understand the needs and partnerships with regional education and research networks. The calls aimed to identify burgeoning computational research efforts and support technical educational programs with strong computing needs. Since its inception in 2020, BRICCs has engaged (and identified) over a hundred possible partners through its workshops, weekly meetings, and campus engagements. The weekly calls are attended by representatives from community colleges, BRICCs leadership, and invited speakers. Topics include upcoming training and funding opportunities, research initiatives at community colleges, and collaborative planning for the annual in-person workshop. Annually, in-person workshops foster the community aspect. These events are planned and executed by the BRICCs community, ensuring that the topics stay relevant to BRICCs stakeholders and maximize the impact. To reduce the barrier of entry, all workshop participants are paid for travel by the BRICCs grant. Findings from each workshop are collated into a report that is disseminated to federal funding agencies such as the NSF to help inform future solicitations of the needs of community colleges and to the CI community as a whole through venues such as the Practice and Engagement of Advanced Research Computing (PEARC) [13] conference series and at the bi-annual meetings of the Coalition for Advanced Scientific Computing (CASC) [3].

The BRICCs team has raised awareness of the opportunities offered by incorporating CI at under-resourced institutions by hosting three workshops, participating in conferences, facilitating proposal submissions, authoring publications, hosting information resources, working with State agencies, and partnering on collaborations for CI focused on renewable energy. We have learned that improved campus computing resources (human, physical, digital, networking,

and administrative) offer compelling ways to engage students and faculty in research. In the process, we have also discovered that while 2-year and 4-year schools have different business models, there are means to engage these schools in CI that expand beyond traditional models of researcher-centric CI support by groups such as CASC, CaRCC [2], and NSF ACCESS. For CI expansion into 2-year schools to succeed, individuals such as the President, Provost, and other high-level administrators must also be included. BRICCs has found Champions at these institutions from various academic disciplines, serving as reminders that engagement in these settings should be cross-disciplinary. We have found that there can be significant differences between 2-year colleges, and a one-size-fits-all approach may not work for all of them. Not surprisingly, we have received requests to support state and regional initiatives in the Greater Houston Metropolitan area (population 7.1 million), New Mexico, Tennessee, and the Navajo Nation.

The first workshop, held in Levelland, Texas, in 2021, conducted a landscape study to identify the steps that need to be taken by BRICCs, various funding agencies, and the general CI community to address the technology gaps and research computing needs. This meeting had several key findings. First, two- and four-year institutions differ in their structural organization and primary objectives. These differences must be understood when establishing collaborative efforts between institutions of different types. Second, smaller and more rural colleges do not have the infrastructure or financial resources to house or maintain large-scale computing resources. These limitations should be taken into consideration when drafting calls for funding opportunities. Next, many opportunities, both realized and unrealized, are available to incorporate research computing into curricula at smaller institutions. These institutions, especially community colleges, must collaborate with local industries to build a curriculum using research computing that provides relevant vocational training. Also, the mechanisms by which CIOs communicate with research faculty and institutional administrators must be developed and refined at institutions of all sizes. Although we identified several potential hurdles and caveats that need to be addressed, we found strong evidence that regional collaborations between R1 universities, RENs, and smaller institutions can accelerate the incorporation of research CI community colleges and underserved 4-year universities.

The second workshop, held in August of 2022 in Corpus Christi, Texas, focused on developing collaborative computing resource models to facilitate relationships between larger and smaller institutions, and we identified several opportunities for growth in these endeavors. First, relationships between lead institutions assisting with research at smaller colleges and universities vary greatly between regions and within articulation agreements. Some well-established research universities can successfully develop these fruitful collaborations with two- or four-year institutions while emerging R1 institutions might still be struggling to establish CI resources and cybersecurity at scale. We proposed these institutions work together to develop cohesive CI curricula to strengthen inter-institutional relationships and to incentivize research at smaller institutions by helping them adopt CI technologies [7]. Second, students must actively engage with CI in their academic courses to be well-trained for the modern workforce. This will involve working with partner institutions and local industries to ensure that coursework involves access to CI resources. Lastly, we found that RENs and regional centers provide a tested framework for these types of collaborations, and they have already worked through many of the challenges faced by smaller colleges and universities and nascent research institutions. The lessons learned by these organizations can serve as a roadmap for others in establishing CI resources [6] [7].

In addition to a regional focus, BRICCs researchers are keen to form affinity groups on thematic topics such as cybersecurity, networking, inclusivity, and data sciences. We recognize that this work must be grounded in regional efforts. This ensures flexibility to conform to state- and local mandates on recruiting zones, articulation agreements with regional four-year institutions, funding structures, ties to local industries, regional networking connectivity, and State-established curricular standards.

Herein, we present the findings from the 2023 BRICCs Collaborative Strategies Workshop held in Santa Fe, New Mexico. The focus of this meeting was to disseminate information regarding learning resources, support for potential funding, and the development of collaborative computing models to address challenges in adopting CI research at all levels of academia. The impact of BRICCs has continued to grow since the inaugural meeting in 2021, and the institutions represented throughout the series include Hispanic Serving Institutions (HSIs), Historically Black Colleges and Universities (HBCUs), and Tribal Colleges and Universities (TCUs). The latest meeting hosted attendees from 41 institutions across 17 states (Figure 1).

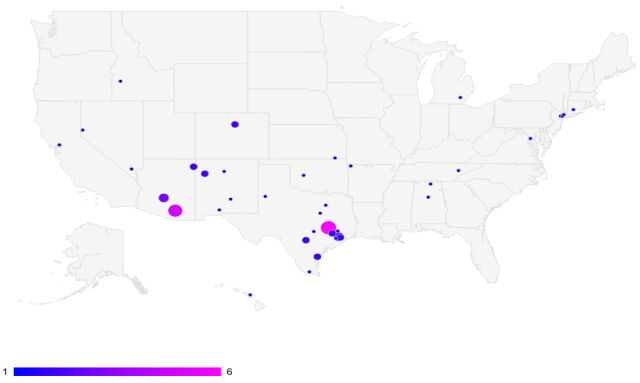

Fig. 1: Geographic representation of attendees at the 2023 BRICCs Collaborative Strategies Workshop

3 OVERVIEW OF FINDINGS AND NEEDS

Some of the major issues that we have identified for community colleges to participate in the CC* program are (i) Lack of administrative familiarity with research funding and the NSF grants process, (ii) Lack of expertise of IT staff who have the bandwidth to develop a campus CI plan; (iii) Lack of communication channels between R&E network groups, local flagship universities and community colleges at the CIO and Enterprise IT level; (iv) Limited faculty expertise in developing infrastructure grants that can stand up to

strict NSF review standards. Faculty need assistance in collecting data to identify needs on campus, planning campus and regional engagements to participate in collaborative NSF grants; (v) With research grants not being a campus priority, it is a challenge for most community colleges to prepare a strong proposal to a solicitation within the 90-day window. Much like at teaching intensive four-year institutions, professors at CCs have a high teaching load (typically five courses), and administrators are often overburdened; (vi) There is almost no access to advanced CI for instruction and learning. The primary findings and needs from the 2023 BRICCs workshop in Santa Fe can be summarized in the following five topical areas:

3.1 Engagement with faculty, campus enterprise IT, and campus researchers

We observed significant potential for collaboration with instructional faculty to identify curricula that could benefit from Computing Infrastructure resources. These resources facilitate active learning environments and pedagogical techniques such as flipped class environments, scaffolded learning using Jupyter notebooks, and technologies like containers that aid instruction in Data Sciences and AI/ML. The workshop highlighted the benefit of campus CI working closely with Campus Enterprise IT, especially when designing network implementations. Tools like Perfsonar were useful for monitoring network traffic and assisting in designing campus networks aligned with institutional missions. With regard to engagement with campus researchers, researchers need to keep up with new HPC and cloud computing technologies such as containers, cloud computing virtual machines, and integrated storage solutions. There is an opportunity to ease the learning curve to these new technologies by connecting them with national advanced CI resources and teams like NSF MATCH, NSF RAMPS, NSF ACES, RMACC, and the NSF SWEETER Cyberteams [5], which provide a variety of consultation, training, and education services as well as networking.

3.2 Cybersecurity

The continuing spate of cyber-attacks on government agencies, cities, facilities, and educational institutions has emphasized the need for existing relationships between various computing groups. Therefore, this area requires an emphasis on regional collaborations.

3.3 Access to Resources and last-mile connectivity

A common thread among participating institutions was the lack of resources at non-R1 institutions. Resources ranged from compute and storage mechanisms to grant writing infrastructure and last-mile connectivity. While some of these resource needs can be met at R1 institutions, some institutions have expressed a need to develop CI resources locally rather than just access regional and national resources. The latter are important, but they need to develop capacity and expertise on campus to develop programs on campus independently. Preparing them for efficient and effective use of regional and national resources is also important.

A major hurdle regarding access to resources is ensuring that students and faculty have reliable access to a fast and secure network. For smaller institutions that serve urban communities, this is less of a concern than those that serve more remote or rural regions, the latter of which suffer from a lack of connectivity unappreciated by most. Therefore, the institutions that serve these communities must work with their RENs and national funding agencies to expand networks into areas that will reduce these inequities. We understand the difficulties outlined in this charge and believe this is the largest hurdle facing many small rural two- and four-year institutions, especially those serving historically disenfranchised and underrepresented communities. However, partnering with RENs and/or large R1 universities will provide a larger voice to advocate for these underserved communities. This will also benefit larger institutions by increasing the pool of talent from which it will gain future students; the prosperity of all large universities depends on the underlying education and interest of the community they serve.

3.4 Power of collaboration for regional research initiatives

This work has clearly demonstrated that smaller institutions can benefit directly from participating in annual workshops like BRICCs. These in-person meetings will allow researchers and administrators to network across R1s, RENs, two-year colleges, and underserved four-year institutions. This community is an invaluable resource for those seeking to promote or gain access to advanced CI at their home institution. Direct interactions with colleagues participating in these workshops help attendees identify common problems or roadblocks they might encounter, as well as examples of past solutions or ideas on how best to mitigate these issues.

Smaller institutions can also benefit from focused collaborations between research groups they house and research groups with similar interests or goals at larger R1 institutions. These collaborations can provide mechanisms by which students at underserved institutions can gain access to advanced CI resources. It also bolsters the research being conducted at both institutions and provides students with an understanding of how research is conducted outside of their group and institution. These collaborations are especially beneficial if the groups host virtual meetings at regular intervals, allowing students and researchers alike to share progress and feedback on various aspects of the research.

Another avenue of collaboration between research faculty and students at smaller institutions and larger universities is local outreach and education. This practice will benefit both institutions as the communities and regions they serve will better understand the need for advanced CI and the opportunities it presents. Working together, several institutions can offer K-12 outreach programs and community events that will serve the missions of both organizations.

Community colleges may benefit from the inclusion of R1 personnel on advisory committees. These committees, consisting of college administrators and local industry representatives, ensure that the curriculum offered by the community colleges aligns with the workforce needs. Through direct contribution and articulation agreements, R1 support in this endeavor will strengthen the academic institutions and better prepare the students for work following graduation.

3.5 Outreach

National computing ecosystems like ACCESS (Advanced Cyberinfrastructure Coordination Ecosystem: Services & Support) [1] and that proposed by NAIRR [14] provide researchers across the nation access to CI resources. Unfortunately, there is a lack of awareness of these programs, even at institutions that provide access to these resources. Given this, programs that provide regional dissemination of these resources are critical; BRICCs and SWEETER (SouthWest Expertise in Expanding Training Education and Research) [10], [5] are two such programs that have been actively engaged in promoting these resources. The 2023 BRICCs Collaborative Strategies Workshop held a session dedicated to introducing attendees to the ACCESS ecosystem. A separate workshop, hosted by Texas A&M HPRC and SWEETER, provided users access to these nationally available systems and training in various areas of HPC, including Python, AI/ML, CUDA, and data science in R [9].

A key point of discussion at the annual BRICCs meeting was the lack of awareness regarding these resources. ACCESS promotes its services through programs like CCEP (CSSN Community Engagement Program), which offers travel support to researchers that provide services like community engagement and documentation. Still, these efforts are ongoing and have not impacted many smaller institutions. RENs, like LEARN (Lonestar Education and Research Network), The Quilt, NJEdge, and NevadaNet, play a critical role in spreading awareness of these resources and are a great mechanism for facilitating conversations and collaborations between colleges and universities. The Campus Research Computing Consortium (CaRCC) is vital in promoting research computing and data (RCD) across the educational community.

4 RECOMMENDATIONS

We, however, need a mechanism for everyone to learn from each other. We need a scalable framework to support them! The current community college education is vastly different from the colloquial understanding of the experience of these students. Community college students are exposed to an expansive array of career opportunities with training highly specialized to their field of choice. Community colleges have strived to keep pace with the advanced technological needs of open workforce positions, and many institutions are excelling in this endeavor. These institutions could greatly benefit from access to the CI resources held by larger R1 universities. In conjunction with the findings and needs discussed in the workshop, the following were identified as possible strategies for mitigating the needs presented.

- To effect successful collaborations between R1s and community colleges, each participating institution must be able to articulate what it expects to gain from the collaboration. In this regard, it was recommended that collaborations be specific, with specific start and end dates and clearly defined milestones for all participating institutions.
- A pragmatic means by which R1 can effectively assist community colleges is with grant infrastructure. The lack of grant infrastructure on community college campuses, especially roles traditionally covered by an R1's Office of Sponsored Research, is a large impediment to writing and winning grants. Community colleges' ability to use the resources of an R1's grants office would go a long way in helping them pursue federal funding awards.
- Engaging with faculty interested in research at community colleges will also allow students at community colleges to be trained in research methods. That way, when students transfer from the community college to an R1 school, they are already trained in research methods and can hit the ground running. This creates an effective pipeline for training students from community colleges to R1 schools.
- For research collaborations between R1s and community colleges to be successful, there need to be champions at each institution participating in the collaboration. The champions need to be able to clearly articulate the motivations, expectations, and achievements of the collaboration to stakeholders at each institution.
- Research Engagement Networks (RENs) are vital in connecting campuses regionally. They also predominantly have an education mandate for their activities. Therefore, RENs can be valuable resources for community colleges to improve research infrastructure. Furthermore, it was discussed that some RENs sometimes apply for federal funding to solve last-mile connectivity issues, which would be extremely beneficial to campuses in rural areas.
- Regional computing collaborations must focus on cybersecurity and assist in collaboratively developing a set of recommendations, working with active groups like Trusted-CI, and offering implementation details to help inform the larger CI community of the state of CI at two-year institutions while simultaneously alleviating some of the issues faced by smaller institutions as they prepare for the CC* grant submission process.
- For new faculty hires to be the most effective, campuses must engage with them as soon as possible and connect them with a mentor network on campus. These collaborative projects are the most sustainable collaboration on community college campuses.
- Research projects don't necessarily need to originate wholly at community colleges; more realistically, research projects from R1s can be extended to community colleges by addressing local geographic, climate, and other local issues with research applied from projects from R1 institutions.
- One of the major factors identified for success was facilitation. Campuses need facilitators who can serve as a bridge between researchers and IT infrastructure.
- There is a glaring chasm between the abundance of resources available and more importantly, known to the R1 community and the lack of it to community colleges. The Research Computing and Data community needs to be much more effective and intentional in advertising the availability of resources, opportunities for training, grant-writing workshops, and other RCD activities to the community college ecosystem.

5 A MODEL TO ADDRESS NEEDS

It is perhaps heartening to note that our findings and recommendations from the second and third workshops have started to converge.

Needless to say, working with partners at community colleges and smaller minority serving institutions (MSIs), we need to continuously (i) analyze the implementations of current regional connectivity and computing models at smaller four-year universities to understand possible adoption mechanisms to community colleges; (ii) explore current funded models to understand whether anchor agencies are needed for successful implementation; (iii) leverage partnerships and assimilated information to assist two-year institutions apply for funding for CI resources; (i)v study the enterprise IT workflows to find an appropriate balance between network security and research and educational needs; (v) facilitate ongoing communication and coordination among the many existing entities and the community at large to identify CI challenges (like shared data sets) that should be tackled at the regional level; and (vi) explore means to broaden participation in computing among students at these institutions.

As we hear from more institutions, we realize we must find a mechanism to support these burgeoning efforts. In the future, we propose a collaborative effort that brings the combined expertise of stakeholders under a single setting to expand institutional CI at two-year schools. We need to represent the needs of a growing but previously overlooked community. As such, it is important to ensure that the community's aspirations are articulated in the vision, mission, values, and charter of BRICCs. The goals will be to (i) raise awareness of the value of utilizing CI resources at two-year institutions, (ii) host shared community resources that expand from educational to computing resources, (iii) offer pathways for active CI communities to engage with BRICCs researchers and institutions; (iv) establish pathways for shared training and research programs to assist in the development of student- and researcher-preparedness in CI; (v) facilitate regional collaborations by providing mentorship and technical solutions; (vi) engage in preparatory efforts for technology entrepreneurship, (vii) develop programs that expand the reach of CI to under-served and under-represented communities, and (viii) be an informed participant in discussions of national CI.

We note that several under-resourced four-year institutions also need these resources. A federated model where a central group offers a common pool of resources and expertise from which regional centers can draw could be considered. Regional centers will have the flexibility to conform to state and local mandates regarding recruiting zones, articulation agreements with regional four-year institutions, funding structures, ties to local industries, regional networking connectivity, and State-established curricular standards. This is inspired by the hub-and-spoke approach of NSF's Big Data Hubs program. An Advisory Board composed of stakeholders will guide the effort. The central coordination office will support the regional efforts and learn from them. This approach enables regional groups to develop their own capabilities at their own pace while alleviating several one-off studies. Furthermore, this structure allows regional synergies between 2- and 4-year institutions to flourish. Cross-cutting interest groups will form between regional groups on topics such as cybersecurity and student engagement. This will facilitate research collaborations.

Here we highlight some of the activities that such a group would enable:

- Promote student and researcher support programs at BRICCs schools via facilitated mentorships with faculty and CI professionals at research-intensive institutions. Opportunities include (a) developing a CI-mentorship network for researchers and faculty, (b) Research experience for undergraduates, internships, and other guided experiences for students, (c) opportunities for students and faculty to earn micro-credentials, (d) sponsoring travel for student teams (cluster competitions) and researchers to CI conferences.
- Facilitate ongoing communication and coordination among existing CI entities and IHEs by managing digital resources such as the BRICCs website, authoring publications, and maintaining mailing lists. Organizing a national conference to offer the community opportunities to learn from each other. Success stories, student engagement programs, and approaches to connect to national programs will be discussed at this event. Training on CI preparation will also be offered.
- Organize CI summits to help new community members become conversant in CI technologies. This avenue will give attendees opportunities to discuss partnerships, learn how to develop institutional CI policies, hear from other CI-focused communities, and identify ways to engage students in research. These engagements will seed collaborations between two-year institutions and other groups in pursuit of funding to further their CI ecosystems.
- Serve as a managed information hub for resources and activities to help students and researchers from different disciplines develop core competencies in research CI. Facilitators will prepare and manage micro-credentials, security policies, and workflows that can be incorporated into class projects.
- Build a pathway to national CI resources. A possible pathway could be offering a shared data and computing resource as a launching pad for educational and technical programs. As programs mature, they could be onboarded to larger national resources via NSF ACCESS, PaTH/NRP, and large facilities at TACC and NCAR.
- Working with RENs, develop frameworks for collaborative computing models for community colleges. While RENs offer a path to engagement with these IHEs, not all RENs can offer shared regional computing services to these schools. Exploring, documenting, and recommending business models could inform the activities of groups such as Internet2, National Research Platform, Educause, League of Innovation, CaRCC, Quilt, and ACCESS about the opportunities for researcher engagements here.
- Continue the work started by organizations such as NSF CORD [8] by informing External Advisory Boards about job prospects and the skills required for CI-professional positions. Curriculum design and the mission of community colleges are driven by engagements with local industry and their External Advisory Boards. They are simultaneously keen to learn how to set up CI-enabled programs at community colleges in fields like Data Science and Cybersecurity.
- Engage with Chambers of Commerce, industry, and NACCE to create CI entrepreneurial hubs for students. There are opportunities to partner with NSF Regional Innovation Engines and NSF I-Corps programs in preparation for future

submissions to the Small Business and Technology Transfer program.

6 DISCUSSION AND FUTURE WORK

Insights from computing have transformed work, education, scientific inquiry, industrial practice, economies, and how we live. Computing is the pathway toward building interinstitutional and multidisciplinary collaborations. Today, HPC accelerates discovery and innovation across the sciences - organizations like BRICCs [10] and SWEETER [5] make this possible at institutions of all sizes. Computing is proving to be the new medium for growing nascent research programs. BRICCs benefits from including CCs when exploring ways to incorporate cloud-computing curricula to accompany existing programs in cybersecurity. As student choices to attend community colleges may be driven by social considerations, personal finances, and the ability to take classes on a flexible schedule, we need to offer pathways for these students to fulfill their academic, social, and research aspirations. These colleges need to offer opportunities for academic and research pursuits. The challenges in adopting advanced CI at community college campuses offer opportunities for innovation that are not possible at 4-year institutions. Here, we note that regional computing efforts, like the NSF CC* Launch program, have a major role to play. Launch features an intuitive interface and policies that welcome everyone new to HPC. In the future, we hope that the Launch supercomputer, supported by the NSF and hosted by HPRC, supports the academic and research ambitions of BRICCs and our other academic partners.

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