An Evaluation of Cyberinfrastructure Facilitators Skills Training in the Virtual Residency Program

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ABSTRACT

Cyberinfrastructure (CI) Facilitation amplifies the productivity of researchers engaged in computing-intensive and data-intensive investigations. CI Facilitators help researchers to adapt their workflows to CI resources, and teaches these researchers how to use these systems, bridging between researchers and technology experts. The importance of CI Facilitators is well understood, and there is broad consensus about their need for ongoing training, especially because of not only their highly diverse career backgrounds and domains of expertise, but also the rapid advancement of CI technologies. The Virtual Residency Program (VRP) has been addressing this training gap since 2015, offering summer workshops that teach key CI Facilitation skills. These workshops are community driven and community developed. The 2020 VRP workshop, for the first time, featured an external evaluation of the efficacy and value of the workshop. This paper examines the results of that evaluation, to determine the value of the VRP to the CI Facilitator community, and thus to the many researchers these CI Facilitators serve.

Since 2015, all VRP activities collectively ave had a total of 953 participants, from 381 institutions in every US state and 3 US territories plus 12 other countries on 5 continents.

CCS CONCEPTS

• **Social and professional topics** → **Computing occupations**; **Adult education**.

KEYWORDS

Cyberinfrastructure workforce development, research computing facilitation, Cyberinfrastructure facilitation, training

1 INTRODUCTION

Cyberinfrastructure (CI) Facilitators are CI professionals who work directly with Science, Technology, Engineering and Mathematics (STEM) and non-STEM researchers (e.g., humanities), to advance the computing-intensive/data-intensive aspects of their research. CI Facilitation amplifies researcher productivity via:

- adapting researcher workflows to CI systems (e.g., supercomputers, clouds, storage) and teaching how to use these systems;
- bridging between researchers and technology experts;
- anticipating new CI needs for emerging research activities (e.g., GPUs for machine learning);
- helping STEM researchers with limited coding experience to design use-case-specific software and to port to advanced architectures;
- teaching research cybersecurity and compliance (e.g., HIPAA for grants);
- developing strategies for specific use cases;
- teaching data management;
- providing local and national training opportunities (e.g., Software Carpentry workshops [7] for novice CI skills);
- helping researchers evaluate technology solutions;
- recruiting new users and new use cases;
- researcher advocate to central administration;
- preparing CI-focused portions of publications, posters, etc;
- composing CI text for grant proposals.

CI Facilitators come from a variety of backgrounds and education levels, including current and former (a) faculty, (b) recent graduates, (c) enterprise IT professionals, and (d) research professionals, from bachelors level to PhD level, in every STEM discipline (not primarily Computer Science [15]).

The need for CI Facilitation is seen in a recent survey of CI Facilitators [12], who estimated a mean of approximately 1800 researchers served per CI Facilitator over their CI Facilitation careers (mean 16.4 years). To the nearest order of magnitude (because of multiple CI Facilitators per researcher), CI Facilitators expect to serve on the order of a million researchers over their careers. Similarly, CI organization leaders – e.g., High Performance Computing (HPC) center directors – see the need for CI Facilitation, with 87% of them reporting that their CI Facilitators are very important to their computing/data-intensive researchers. [12]

The National Cyberinfrastructure Coordination Service Conference report [4] recommends the following:

> "Incentivize the development of new/ongoing efforts that bring together CI professionals to learn from one another and generate community efforts to identify and improve leading practices."

Similarly, the National Science Foundation's CI 2030 report [9] states:

- "NSF should develop mechanisms to support teaming of scientists and engineers with ... [CI] professionals to ensure that science and engineering [research] benefits from future advances in ... [CI] ...."
- "The skill and knowledge needed to use ... [CI] is very advanced and beyond the reach of most domain scientists. Professionals with [CI] expertise are in very short supply and there is an increasing need for 'bridge' technologists ... with enough domain expertise to understand research requirements and enough technical [CI] expertise to ... develop/apply the right [CI] solutions. Skills development, reliable funding sources, and rewarding career paths are desperately needed for such individuals."

Since 2015, the CI Facilitators Virtual Residency Program (VRP) has been pursuing exactly these goals, via (a) annual summer workshops focused on training in CI Facilitation, (b) VRP workshop planning calls, (c) a Grant Proposal Writing Apprenticeship and (d) a Paper Writing Apprenticeship [13–16]. CI Facilitators are tasked with bridging complex technical, scientific, and engineering projects to the available CI resources as part of diverse teams. Yet while considerable education and training materials are available for the technical aspects of this role, the VRP represents the only resource specifically targeted at the CI Facilitator community that addresses nontechnical skills, especially professional/interpersonal (soft) skills (see sections 2 and 3, below).

Since 2015, all of these VRP activities collectively (along with workshops provided by the University of California system based on the VRP model) have had a total of 953 participants, from 381 institutions in every US state and 3 US territories plus 12 other countries on 5 continents, including:

- 58 Minority Serving Institutions (15% of VRP institutions);
- 103 non-PhD-granting institutions (27% of VRP institutions);
- 100 institutions in 27 of 28 EPSCoR jurisdictions (26% of VRP institutions);
- 254 Campus Champion institutions (67% of VRP institutions, 75% of Campus Champion institutions).

Given this last point, it's clear that the VRP functions as as the *de facto* training program for Campus Champions.

An indirect measure of the value of the VRP is its repeat rate. Specifically, for institutions that have participated in VRP activities:

- 78% of VRP institutions have participated in multiple VRP activities;
- 74% of VRP institutions have participated in multiple types of VRP activities (at least two of workshops, VRP calls, grant proposal writing calls, paper writing calls).

2 VIRTUAL RESIDENCY WORKSHOPS 2015-2019

Since 2015, the VRP has held annual summer workshops, funded primarily by National Science Foundation (NSF) grants (see Acknowledgements, below). The 2015-19 workshops [12–15]. were all held in hybrid mode, with both onsite in-person participants and remote participants via videoconferencing. These workshops collectively covered three levels:

- Introductory: Material appropriate for pre-service or novice CI Facilitators, focused on basic understanding of CI Facilitation tasks, researcher needs, and communicating with researchers.
- Intermediate: Material appropriate for experienced CI Facilitators, focused on deeper understanding of how to provide CI Facilitation.
- Advanced: Material focused on institutional CI leadership.

Workshop attendance 2015-19 was as follows:

- 2015: Introductory: 50 participants (28 onsite, 22 remote) from 39 institutions in 26 US states and 1 US territory, with 18 speakers, moderators and panelists from 6 institutions.
- 2016: Introductory: 100 participants (43 onsite, 57 remote) from 60 institutions in 33 US states plus 3 other countries, with 22 speakers, moderators and panelists from 11 institutions.
- 2017: Introductory: 196 participants (51 onsite, 145 remote) from 134 institutions in 47 US states and 2 US territories plus 3 other countries, with 20 speakers, moderators and panelists from 17 institutions.
- 2018: Intermediate/Advanced: 216 participants (38 onsite, 178 remote) from 147 institutions in 43 US states and 1 US territory plus 2 other countries, with 34 speakers, moderators and panelists from 28 institutions.
- 2019: Introductory/Intermediate: 254 participants (37 onsite, 217 remote) from 162 institutions in 45 US states and 3 US territories plus 5 other countries, with 43 speakers, moderators and panelists from 35 institutions.

Session topics for the 2015-19 workshops are found in [12–15].

3 VIRTUAL RESIDENCY WORKSHOP 2020

The 2020 VRP workshop was a mix of intermediate and advanced material, because of the desire to incorporate material from the Cyberinfrastructure Leadership Academy [3], held in February 2019. The 2020 workshop was held entirely via videoconferencing, because of the COVID-19 pandemic, so structurally it differed significantly from the 2015-2019 workshops. On the one hand, this all-videoconferencing approach eliminated opportunities for in-person networking; on the other hand, it led to improved availability of speakers, panelists and panel moderators, with a total of 94 presenters from 67 institutions, which is more than double the previous record for presenters and almost double the previous record for presenter institutions.

Because of COVID-19, presenters were able to participate who might not otherwise have been able to, providing greater breadth of participation from organizations and individuals at more levels of the CI/researcher/stakeholder hierarchy, from new Virtual Residents to current and former Chief Information Officers and Vice Presidents of Research. Of the 2020 VRP workshop's 94 presenters, moderators and panelists, 62 (66%) hadn't presented at previous (2015-19) VRP workshops, so they were able to provide novel points of view.

Presumably because of the all-videoconferencing format, the 2020 VRP workshop [12] had a record-smashing 430 attendees from 225 institutions in 49 US states and 3 US territories plus 7 other countries, including:

- 31 Minority Serving Institutions (14% of institutions participating in the 2020 VRP workshop);
- 44 non-PhD-granting institutions (20% of institutions);
- 65 institutions in 26 of 28 EPSCoR jurisdictions (29% of institutions);
- 171 Campus Champion institutions (76% of VRP institutions, 51% of CC institutions).

3.1 2020 Workshop Content

3.1.1 Facilitating AI/Machine Learning/Deep Learning. The goal of this panel was to discuss best practices for facilitation, resource design and which disciplines are at which levels of experience, based on system requirements. The panel's aim was to educate users and facilitators on HPC work within this environment, and how system design can align with students, educators, staff and outside audiences.

3.1.2 Things I Wish I'd Known Before I Became a CI Leader. This session was derived from the CI Leadership Academy [3], and featured CI Leadership Academy attendees or their proxies. Questions provided to the panelists included:

- If you could go back in time and talk to your younger self when they were just starting as a CI leader, what advice would you give them?
- If you were talking to a brand new CI leader right now, would you give them the same advice? If not, what advice would you give them?
- What's one of the dumbest mistakes you made when you were starting out as a CI leader, and what did you learn from it?
- What's one of the smartest things you did when you were starting out as a CI leader (whether you realized it at the time or not)?
- Did you ever feel like you were part of an underrepresented group (of any kind) during your career, and how have you dealt with that and made sure you support others?
- … In your role as a CI leader, how have you approached issues of diversity, inclusion and equity?

3.1.3 The CI Funding Landscape: Funding Agency Perspectives. This panel was another session derived from the CI Leadership Academy. This panel featured former NSF leaders who had managed programs and projects in the Directorate of Computer and Information Science and Engineering (CISE) and the Office of Advanced Cyberinfrastructure (OAC). They provided their unique perspectives and expertise on the CI funding landscape. The panel's questions focused on (a) strategies to increase odds of funding success and

funding unadvertised opportunities, (b) CI funding from federal, state, and private agencies, (c) stories and motivation for working at the NSF, and (d) the future of CI funding.

3.1.4   Perspectives about CI from CIOs & VPRs. CI Facilitators are sometimes disengaged from CI policy discussions among institutional leadership, and the policy decisions that affect their work do not always appear to them to be strategic. To help CI Facilitators understand the complexity of these decisions and the tradeoffs that are involved, this panel brought together leaders from a wide array of institutions and backgrounds, to describe CI's role and importance in contributing to the mission of their institutions. The panelists were asked to discuss (a) some of the challenges they face in supporting CI, given budget constraints, (b) how CI is prioritized relative to the multitude of other institutional issues they are charged with, and (c) how they gather information about the value of CI to make informed policy decisions.

3.1.5   Building Community. Community leaders were asked to share their experiences in building community. They were first asked to describe why community building matters and how they approached various opportunities and challenges. They were then given an opportunity to offer advice on how to make connections between groups, bring in new members, mentor emerging leaders, and make sure all voices are heard.

3.1.6   CyberAmbassadors: Leading the Change: Equity and Inclusion; Leading with Principles: Ethics. The Equity, Inclusion and Ethics module was developed as part of the NSF-funded CyberAmbassador program [5, 6, 8, 11] and adapted from the Entering Mentoring curriculum funded through the National Institutes of Health [10]. Originally designed to be taught in person with hands on activities and discussions, the module was adapted to work fully online. Two videos describing Implicit Bias were added and shared with the participants ([2], [1]), followed by a group discussion.

3.1.7   Facilitating Cloud Computing. This intermediate panel hosted a diverse group of cloud HPC directors, CI Facilitators, and engineers, who collectively represent the span of most functions and elements of CI Facilitation in the cloud. The panel was asked to cover three major topics:

- Planning for Cloud Adoption and Its Challenges: procurement terms and conditions; account and billing management; compliance, e.g., HIPAA, FERPA, export control; internal cybersecurity assessments; Business Associate Agreements; connecting to public clouds; identity management integration; multi-cloud systems.
- Staffing, Training, Support: organizational structures and staffing models; identifying cloud team candidates; building cloud expertise on campus; support models.
- Cloud Success Stories: cloud use cases that add value to research, teaching/learning, and administrative workloads; leveraging public cloud provider funding programs; understanding higher education programs; RHEDcloud and CloudBank programs.

Lastly, the panel concluded with a question and answer session on related topics; for example:

- What workloads have you seen on traditional CI (e.g. HPC clusters with job schedulers) that would be better suited for cloud resources?
- How are you addressing public cloud integration with on-premises identity management?
- Compare cloud to on-premises expenses – when is the cloud more economic?
- How effective is hybrid HPC cloud bursting?
- What are the challenges of HPC backup and restore in the cloud?

3.1.8   Marketing, Communication, Demonstrating Impact/Value. In this panel, several experts from several universities were asked to share their knowledge, expertise, and experience on effective communication strategies for promoting awareness of CI, identifying the most commonly used resources for research collaboration, and sharing successful (and unsuccessful) outcomes.

3.1.9   Sessions Described Elsewhere. The following sessions were held at the 2020 workshop and are described in [15], [13], [14], and/or [12].

- "Virtual Residency Workshop Overview"
- "Research Data Management for Big Data"
- "Assessing and Anticipating Researcher Needs"
- "Deciding Which Technologies to Adopt, and When"
- "Strategic Thinking & Visioning"
- "Working Effectively with Vendors"
- "Teams of CI Professionals: Recruitment & Retention, Management, Team-building, and Motivation"
- "Explaining Complex Technical Topics to Researchers"
- "Mapping Research Requirements to Software Tools"
- "Research Computing Facilitation for Non-Traditional Disciplines"
- "Sustainability"
- "Stories from the Trenches"

4   EVALUATION

A formative evaluation of the June 2020 VRP Intermediate/Advanced Workshop was conducted by the Georgia Institute of Technology's Center for Education Integrating Science, Mathematics, and Computing (CEISMC), to assess attendee satisfaction and short term outcomes and to guide program improvement. The evaluation team consisted of Dr. Lizanne DeStefano, CEISMC Executive Director, and Lorna Rivera, CEISMC Research Scientist. Two online surveys were administered, a Day 1 survey and a post event survey. Of the 341 attendees on Day 1, 87 (26%) responded to the Day 1 Survey. (The Day 1 Survey was an early, formative check-in to identify any concerns early in the program.) Similarly, 29% of the overall workshop attendees and registrants responded to the post event survey (182/622); this response rate was unusually high for an anonymous, on-line survey with no incentives. Almost two thirds (63%) of attendees indicated that the June 2020 event was their first time attending a VRP workshop.

4.1 Demographics

In terms of gender diversity, 66% self-identified as male, 29% as female and 1% as non-cisgender (Table 1). This compares favorably to demographic information from surveys by other organizations within the Cyberinfrastructure community. For example, (a) 16% of respondents to the Campus Champion 2018 Climate Study self-identified as female [17], and (b) 13-14% of SC15-17 attendees did likewise [18, 19].

In terms of racial and ethnic diversity, non-Hispanic whites represented the largest racial or ethnic group at 60% of attendees, and non-Hispanic Asians were 16%. Self-reported underrepresented racial/ethnic minorities (URMs) collectively represented nearly 18% of attendees (Table 2). This is modestly better than the 14% of Campus Champion 2018 Climate Study respondents who self-identifed as URMs. [17]

Table 1: Self-Reported Gender, N=145

Gender	Percent	Count
Male	66%	95
Female	29%	42
Non-cisgender	1%	1
I identify as [other]:	1%	2
Prefer not to disclose	3%	5

Table 2: Self-Reported Race and Ethnicity, N=154

Race/Ethnicity (Note that respondents could select more than one race/ethnicity to report.)	Percent	Count
White	60%	93
Asian	16%	25
Black or African American	8%	12
Hispanic or Latino	7%	11
Other (please specify)	3%	5
Prefer not to disclose	3%	4
American Indian or Alaska Native	2%	3
Native Hawaiian or Other Pacific Islander	1%	1

4.2 Key Evaluation Findings

Participants reported having a highly positive experience in the workshop, with survey respondents rating the workshop as fulfilling their expectations (Mean 4.40, Scale 1 = strongly disagree to 5 = strongly agree), and indicated the logistics ran smoothly. Respondents noted that each session was conducted as a Zoom meeting. To further improve the virtual format, some participants suggested conducting these sessions as Zoom webinars instead, to avoid issues with muting and unmuting participants.

4.2.1 Session and Satisfaction Ratings. Attendees rated all sessions highly, at or above a mean of 3.90 on a scale of 1 (not at all valuable) to 5 (very valuable). The best rated sessions are in Table 3, below.

Likewise, attendees rated all satisfaction questions highly, at or above a mean of 4.16 on a scale of 1 (strongly disagree) to 5 (strongly

Table 3: Top Rated Sessions

Talk: "Virtual Residency Intermediate/ Advanced Workshop 2020 Overview"			
Mean 4.42	StdDev 0.80	N	106
Intermediate/Advanced Panel: "Assessing and Anticipating Researcher Needs"			
Mean 4.41	StdDev 0.76	N	111
Talk/Practicum: "CyberAmbassadors: Leading the Change: Equity & Inclusion; Leading with Principles: Ethics"			
Mean 4.37	StdDev 0.76	N	89
Advanced Panel: "Building Community"			
Mean 4.37	StdDev 0.77	N	95
Advanced Panel: "Things I Wish I'd Known Before I Became a CI Leader"			
Mean 4.35	StdDev 0.70	N	112

Table 4: Overall Workshop Value

I would recommend this workshop to others			
Mean 4.60	StdDev 0.56	N	161
Overall I would rate my experience as successful			
Mean 4.56	StdDev 0.57	N	162
The workshop fulfilled my expectations			
Mean 4.40	StdDev 0.62	N	159
The knowledge I gained at the workshop will significantly contribute to my work			
Mean 4.16	StdDev 0.74	N	160
The Google doc session discussions were useful			
Mean 4.16	StdDev 0.83	N	148

agree). The questions about overall workshop value are in Table 4, below. Similarly, questions about satisfaction with other issues (technical, logistics, etc) also rated highly, each with a mean score between 4.17 and 4.71.

4.2.2 Session Rating Differences by Demographic Characteristics. Notably, self-reported URM respondents had a similar and at times more positive experience than members of majority groups. In particular, self-reported URMs found the overall experience more successful, and found (a) the Google doc session discussions, (b) "Advanced Panel: The CI Funding Landscape: Funding Agency Perspectives," and (c) "Intermediate Lightning Talks: Explaining Complex Technical Topics to Researchers" more useful than respondents from majority racial/ethnic groups (Table 5).

While still positive, women rated one session lower than men (Table 6).

4.2.3 Session Rating Differences by Role. While still positive, research facilitation staff tended to rate items lower than those in other roles (Table 7). Research Facilitation Staff differed statistically significantly from others on two satisfaction questions and eight session ratings. The ratings for the two satisfaction questions differed by 0.19 to 0.22 points on the 1 to 5 scale, and the ratings for

Table 5: Racial/Ethnic Differences in Item Ratings

The Google doc session discussions were useful							
URM	Mean	4.58	StdDev	0.58	N	25
Majority	Mean	4.07	StdDev	0.85	N	157
$t(146)=2.822, p=0.005$							
Overall, I would rate my experience as successful							
URM	Mean	4.76	StdDev	0.44	N	25
Majority	Mean	4.52	StdDev	0.58	N	157
$t(41.439)=2.408, p=0.021$							
Advanced Panel: "The CI Funding Landscape: Funding Agency Perspectives"							
URM	Mean	4.71	StdDev	0.83	N	25
Majority	Mean	4.20	StdDev	0.86	N	157
$t(82)=2.053, p=0.043$							
Intermediate Lightning Talks: "Explaining Complex Technical Topics to Researchers"							
URM	Mean	4.71	StdDev	0.47	N	25
Majority	Mean	4.19	StdDev	0.93	N	157
$t(36.53)=3.124, p=0.003$							

Table 6: Gender Differences in Item Ratings

Intermediate/Advanced Panel: "Deciding Which Technologies to Adopt, and When"							
Women	Mean	3.85	StdDev	0.99	N	20
Men	Mean	4.27	StdDev	0.75	N	63
$t(81)=2.023, p=0.046$							

the individual sessions differed by 0.26 to 0.65 points. The reasons for these differences are unclear.

NOTE: This evaluation was performed under exemption approval H16227 from the Georgia Institute of Technology Institutional Review Board.

5 FUTURE WORK

The VRP will continue to hold annual summer workshops, with the 2021 VRP summer workshop scheduled for June 7-11 2021. For the first time, this new workshop will be split roughly equally among all three levels (introductory, intermediate, advanced), in order to address the broad needs of CI Facilitators of many levels of experience. The 2021 VRP summer workshop attracted over 100 preregistrations in the first 24 hours after the registration webpage was opened, over 150 in the first four days, over 200 in the first three weeks, and over 400 in the first three months.

Similarly, the Grant Proposal Writing Apprenticeship submitted a proposal in January 2021, and this paper was written by the Paper Writing Apprenticeship, which has had two previous successful submissions [12, 14].

The proposal submitted by the Grant Proposal Writing Apprenticeship focuses on a pilot project for creating a professional development certification program for CI Facilitators, as a logical next step for the VRP.[12] This program would provide a valuable credential for CI Facilitators, both at their current institutions and in future positions at other institutions.

Table 7: Role Differences in Item Ratings

SRF: Staff, Research Facilitation (for example, (Research Computing Facilitator, Research Librarian)							
The workshop fulfilled my expectations							
SRF	Mean	4.28	StdDev	0.59	N	79
Non-SRF	Mean	4.50	StdDev	0.62	N	103
$t(157)=-2.304, p=0.023$							
Overall, I would rate my experience as successful							
SRF	Mean	4.45	StdDev	0.60	N	79
Non-SRF	Mean	4.64	StdDev	0.53	N	103
$t(160)=-2.096, p=0.038$							
Advanced Panel: "Things I Wish I'd Known Before I Became a CI Leader"							
SRF	Mean	4.21	StdDev	0.82	N	79
Non-SRF	Mean	4.47	StdDev	0.57	N	103
$t(110)=-2.025, p=0.045$							
Intermediate/Advanced Panel: "Deciding Which Technologies to Adopt, and When"							
SRF	Mean	3.76	StdDev	0.92	N	79
Non-SRF	Mean	4.41	StdDev	0.70	N	103
$t(90)=-3.87, p<0.001$							
Advanced Panel: "Strategic Thinking & Visioning"							
SRF	Mean	4.00	StdDev	0.95	N	79
Non-SRF	Mean	4.49	StdDev	0.62	N	103
$t(86)=-2.928, p=0.004$							
Advanced Panel: "Building Community"							
SRF	Mean	4.16	StdDev	0.90	N	79
Non-SRF	Mean	4.56	StdDev	0.58	N	103
$t(93)=-2.626, p=0.010$							
Intermediate Panel: "Mapping Research Requirements to Software Tools"							
SRF	Mean	3.60	StdDev	1.15	N	79
Non-SRF	Mean	4.18	StdDev	0.92	N	103
$t(84)=-2.617, p=0.011$							
Intermediate Panel: "Research Computing Facilitation for Non-Traditional Disciplines"							
SRF	Mean	4.08	StdDev	0.85	N	79
Non-SRF	Mean	4.47	StdDev	0.62	N	103
$t(85)=-2.483, p=0.015$							
Advanced Panel: "Sustainability"							
SRF	Mean	4.09	StdDev	0.82	N	79
Non-SRF	Mean	4.47	StdDev	0.62	N	103
$t(77)-2.312, p=0.023$							
Advanced Panel: "Marketing, Communication, Demonstrating Impact/Value"							
SRF	Mean	4.00	StdDev	0.83	N	79
Non-SRF	Mean	4.48	StdDev	0.62	N	103
$t(64)=-2.693, p=0.009$							

Because the 2021 workshop's topics are based on a survey of Virtual Residents about what their highest priorities would be, the 2020 evaluation feedback about which topics were most valuable didn't enter into that decision-making process.

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