Professional Skills to Support Interdisciplinary Work: Lessons Learned from a Successful Collaboration between Universities, Training Programs, and Professional Societies

Dr. Katy Luchini-Colbry, Michigan State University

Katy Luchini-Colbry is the Assistant Dean for Graduate Student Services at the College of Engineering at Michigan State University, where she completed degrees in political theory and computer science. A recipient of a NSF Graduate Research Fellowship, she earned Ph.D. and M.S.E. in computer science and engineering from the University of Michigan. She has published dozens of peer-reviewed works related to her interests in engineering education and graduate student success. Luchini-Colbry is also Co-Director of the national CyberAmbassadors training project and Director of the Engineering Futures Program of Tau Beta Pi, the Engineering Honor Society, which provides interactive seminars on interpersonal communications and problem solving skills. The CyberAmbassadors and Engineering Futures Programs includes a national network of volunteer facilitators who conduct hundreds of sessions serving thousands of STEM students and professionals each year.

Dr. Dirk Joel-Luchini Colbry, Michigan State University

Dr. Dirk Colbry is a faculty member in the Department of Computational Mathematics, Science and Engineering (CMSE) at Michigan State University. Dr. Colbry earned his Ph.D. in Computer Science and his principle areas of research include scientific image understanding and high performance computing.

Professional Skills to Support Interdisciplinary Work: Lessons Learned from a Successful Collaboration between Universities, Training Programs, and Professional Societies

Abstract

In 2017, Michigan State University was awarded an NSF (National Science Foundation) workforce training grant to build a professional skills curriculum for students and practitioners in STEM (science, technology, engineering, math). The curriculum provided free training in communication, teamwork, and leadership skills in the context of interdisciplinary STEM research and practice. The project had three overarching goals: develop new curriculum; test and revise the materials with at least 75 participants; and implement a "train the trainers" program to prepare at least 20 volunteers to use the new curriculum to provide professional skills trainings for their own campuses, employers, and communities.

The initial three-year project was extended across six years due to pandemic-related delays, but the team pivoted to adapt the curriculum for interactive, online, synchronous trainings that were very well received. Once in-person activities resumed, additional facilitators were trained and the program was adopted by other institutions and organizations to provide professional skills training to their own audiences. Nearly 11,000 participant trainings were completed in the first six years of the project, with help from 120 volunteers trained as program facilitators, and several organizations have stepped in to provide ongoing support to continue the training program after the NSF funding ended.

This paper reflects on the lessons learned over the first six years of this project, documenting both the challenges that had to be overcome and the collaborations that led to the success of this workforce training effort. Specific suggestions are offered for building collaborations with individuals, public institutions, and private organizations to create sustainable professional development programs for STEM audiences.

Introduction and Project Goals

The CyberAmbassadors pilot project (NSF Award #1730137) developed, tested and refined highly modular, customizable curricula to help the cyberinfrastructure (CI) workforce build the communications, teamwork and leadership skills necessary for success in interdisciplinary, computationally-intensive work [1]. Cyberinfrastructure refers to both the physical hardware, computing and communications resources required to create the types of advanced computing systems commonly referred to as "supercomputers" as well as to the individuals who have the skills and expertise to develop and maintain these resources. Cyberinfrastructure is an emerging career field, whose initial members were drawn from fields like computer science, engineering, and the natural sciences. The first CI practitioners were often experts in a specific discipline, such as physics, who were pursuing research that required advanced computing hardware and software in order to enable them to gather and analyze massive data sets. These domain experts frequently partnered with specialists in computing hardware, networking, and software engineering who could assist in building computational systems capable of delving into what are now commonly called "big data" questions.

As the data sets and computational tools increased in size and complexity, the CI workforce began to recognize different specialties and common roles within computationally-intensive research projects. For example, "systems-facing" or "data-facing" CI professionals might have deep expertise in the hardware, software, storage systems, communications, and networking resources required for gathering, analyzing, and storing massive data sets. A "researcher-facing" CI professional, often called a "research facilitator,"

might specialize in helping disciplinary experts use advanced CI to further research in their domain [2]. For example, a research facilitator might work with a plant biology researcher to identify or create data sets containing plant images, location information, and weather logs and then help the researcher leverage or develop software tools to extract specific data relevant to their research questions. In order to work effectively across disciplines, CI professionals need not just technical skills but also the ability to communicate effectively, work in interdisciplinary teams, and lead complex, computationally-intensive research.

Providing training in these professional skills was the focus of the CyberAmbassadors pilot project funded by the National Science Foundation in 2017. The project had three specific objectives:

1. Develop curriculum to provide CI professionals with training in communications, teamwork and leadership skills within the context of large scale, computationally-intensive, and multidisciplinary research across STEM (science, technology, engineering, math).

2. Pilot, evaluate and revise the curriculum by offering training at college campuses and federally funded research facilities, and through partnerships with professional organizations.

3. Create a process to "train the trainers" that prepares volunteers to use the curriculum materials to offer communications, teamwork and leadership training to their own communities.

While the NSF call for proposals focused on developing the CI workforce, as part of the sustainability plan the original pilot project partnered with a professional society to expand the training more broadly across STEM students and professionals. This provides ongoing support for the project after the conclusion of the NSF funding, and has the added benefit of expanding awareness of CI career opportunities to STEM audiences from which much of the current CI workforce is recruited.

Results from the Pilot Project

The original proposal was for a three-year project that would provide in-person training for approximately 225 participants and would recruit at least 20 facilitators for the "train the trainers" experience. Due to the global pandemic, the project was extended to six years and the curriculum was adapted for synchronous, interactive, online delivery. This allowed the program to reach national and eventually global audiences, far exceeding its original participation goals. While not part of the original proposal, a non-credit certificate program was initiated in 2021 recognizing participants who completed at least 9 hours of training across the entire curriculum. Table 1 summarizes the project's outcomes in its first six years.

Table 1: Summary of CyberAmbassadors Pilot Project Training Outcomes

Academic Year	Total Sessions	New Trained Facilitators	In-Person Participants	Remote Participants	Total Participants	Certificates Earned
2017-18	3	2	88	256	344	n/a
2018-19	34	26	713	743	1,456	n/a
2019-20	36	19	547	277	824	n/a
2020-21	45	0 (pandemic)	58	1,861	1,919	72
2021-22	83	34	720	1,430	2,150	160
2022-23	167	40	1,990	2,227	4,217	187
Totals	**368**	**121**	**4,116**	**6,794**	**10,910**	**419**

The CyberAmbassadors pilot project was able to exceed its initial expectations thanks to enthusiastic participation from a national network of CI professionals and students. The first pilot training was hosted by the 2017 Virtual Residency program [3], and 19 volunteer facilitators from 11 states served as "Founding Fellows" for the project, helping to test and refine the initial curriculum. The CyberAmbassadors pilot also included a "train the trainers" effort to prepare volunteer facilitators to use the curriculum to offer professional skills training for their own campuses and communities [4].

The final curriculum includes more than 24 hours of activities across nine sessions, which are organized into three themes: Communications, Teamwork, and Leadership.

- Communications – First Contact: Communicating with Purpose
- Communications – Let's Talk: Communicating about Problems
- Communications – It's Complicated: Communicating about Complexity
- Teamwork –Teaming Up: Effective Group and Meeting Management
- Teamwork – Speaking Up: Effective Presentation Skills
- Teamwork – Leveling Up: Problem Solving and Decision Making
- Leadership – Leading the Team: Understanding Style and Personality
- Leadership – Leading the Change: Equity and Inclusion
- Leadership – Leading with Principles: Ethics

During the pilot project, the CyberAmbassadors training was hosted by more than 40 unique groups, including professional societies (e.g., Research Data Access and Preservation Association, Theta Tau Professional Engineering Fraternity, Vertical Flight Society, Pharmaceutical Engineering Student Society, CaRCC, Society of Asian Scientists and Engineers, Society of Women Engineers); disciplinary conferences (like ACS, ASEE, PEARC, NAU T3; Internet2; Great Plains Network Conference); universities (including Michigan State University, University of California, University of Puerto Rico Mayaguez, University of Tennessee, University of Wisconsin); research facilities (NCSA, NCAR, Jackson Laboratory); and as part of outreach activities like the Mississippi Coding Academy. The CyberAmbassadors materials were also adopted as the core curriculum of the professional development program of Tau Beta Pi (TBP), the Engineering Honor Society. This partnership with TBP was part of the sustainability plan for the CyberAmbassadors pilot; as a non-profit TBP is committed to hosting the open-source CyberAmbassadors curriculum materials and ensuring that they will continue to be freely available to interested facilitators and participants.

Although the pilot project wrapped up in summer 2023, the CyberAmbassadors curriculum continues to be used regularly by trained volunteer facilitators. In the first eight months of the 2023-24 academic year, 117 trainings have been completed by 29 different facilitators, serving almost 2,900 participants. These trainings include a for-credit graduate course at Michigan State University; "Engineering Futures" professional development sessions hosted by TBP for universities in Indiana, Iowa, Georgia, Kansas and Michigan; certificate programs (including 9+ hours of training) offered by the National Center for Supercomputing Applications and by Michigan State University; and the first fully-remote "train the trainers" workshop, which prepared 13 new facilitators from five US universities and the University of Nigeria. The CyberAmbassadors curriculum is also being used to provide professional development as part of several ongoing federally funded projects: CIREN, the Cross-Institutional Research Engagement Network (NSF Award #2230106), at Arizona State University and the University of Tennessee Knoxville; a data science workforce development effort by MSU and Spelman College (NSF Award #2123260); and the CCIFTD CyberTraining pilot project to recognize professional skills credentials within the CI workforce (NSF Award #2118193).

While the CyberAmbassadors exceeded its original goals, the project team encountered a number of unexpected challenges along the way. In hindsight, they can be roughly grouped into three areas:

- Requests from and concerns identified by training participants
- Needs of volunteer facilitators
- Logistical and administrative hurdles

The next several sections describe lessons learned in these areas in more detail, and offer actual or planned solutions that may be of help to others developing and managing similar training programs.

Integrating Participant Feedback

As part of the pilot project, data were gathered about participants' experiences and satisfaction with the training program [5]. Formative feedback gathered during early pilot tests of the new curriculum was used to revise and improve the materials, and participants reported high satisfaction levels with the final CyberAmbassadors. While the pandemic created numerous challenges, by pivoting to fully-online delivery half-way through the curriculum development process the project team was able to gather feedback from a much larger and broader audience than might have been available from the original plan, which focused on in-person trainings.

In part due to demand for online trainings, a series of three-hour, synchronous, interactive sessions was developed covering the entire CyberAmbassadors curriculum. These online trainings proved to be very popular, with thousands of participant trainings serving a global audience. Many participants signed up for multiple training sessions, and those who completed the entire nine-hour training series began to request recognition of that milestone. Although not part of the original pilot proposal, an *ad hoc* certification process was implemented using webforms and spreadsheets to track attendance. This certificate was first offered in July 2021, and in the first three years it was completed by more than 500 participants. As of April 2024, almost 470 additional individuals have made substantial progress towards the certificate (completing at least 1/3 of the required training).

Clearly, there is strong interest in this non-credit certificate program. However, the spreadsheet-based, manual tracking system that was developed during the pilot is not scalable or sustainable. This type of administrative support may be available through TBP, which has already adopted the CyberAmbassadors curriculum as the core of its professional development program, and thus has an interest in making the non-credit certificate freely available to broad audiences in the longer-term. Ideally, TBP will assume responsibility for hosting the CyberAmbassadors curriculum materials (i.e., making them available to facilitators and/or participants as appropriate); helping to match facilitators with training requests; and maintaining attendance records and sending certificates as they are earned. The project investigators are actively working towards this goal with TBP, but fully transitioning administrative responsibilities will take significant time and effort.

One of the most common requests we received from participants was for written materials to supplement the training. The curriculum developed during the pilot project consists of a series of Google slide decks, which include extensive facilitator notes and offer multiple activities and examples for customizing the training to different audiences and formats (e.g., online versus in-person). There are also handouts, rehearsal/role-playing cards, and other materials to accompany different training activities. Participants can request copies of the slide decks, and we send a copy of all the slides with the certificate for those who complete the entire training. However, many participants have asked for a more comprehensive resource covering the entire program – ideally with additional information and references for those who wished to learn more than what could be covered during a training.

One way to meet this need would be to convert the curriculum materials into open-source, freely available, electronic textbooks. Such textbooks could also complement ongoing efforts to use the CyberAmbassadors curriculum in both credit- and non-credit learning opportunities at various universities and research facilities; and could make the program materials available even to readers who are not able to access the facilitated trainings. However, writing these textbooks would be a significant undertaking, as the current materials are the type of limited, "bullet list" resources appropriate for presentations – but not easily consumed by a human reader.

Building a Community of Volunteers

The pilot proposal included a "train the trainers" component to prepare volunteers to use the CyberAmbassadors curriculum to offer Communications, Teamwork and Leadership training for their own campuses and communities. Five in-person "train the trainers" workshops were held during the pilot, each including two full days of activities organized by the investigators at their home campus. In addition to teaching participants how to access and use the CyberAmbassadors curriculum materials, this training experience also helped participants develop more general facilitation skills that could be used in many situations. Examples include learning how to make content more accessible (subtitles/captions; visual contrast; word choices; etc.); how to select and pace activities to foster engagement and learning; how to adjust content for different audiences (e.g., undergraduates; CI professionals; faculty research mentors); and how to make trainings more inclusive by using diverse examples and incorporating a variety of perspectives. More than 120 facilitators were trained by the investigators as part of the pilot project, and in November 2023 the investigators adapted the materials for online delivery and trained an additional 13 new volunteer facilitators from five US institutions and the University of Nigeria. While there is significant potential for growth, in order to continue "training the trainers" in the longer term it will be necessary to develop a full, stand-alone training program that could be implemented by volunteers (not just the project investigators). This would be a substantial effort, requiring the development of full slide decks with extensive facilitation notes along with customized materials and activity guides.

To illustrate the impact of the "train the trainers" approach, consider that the first group of trained facilitators in the pilot project included one employee from the National Center for Supercomputing Applications (NCSA) at the University of Illinois Urbana-Champaign (UIUC). This individual returned to their campus and, in the midst of a global pandemic, launched an online, synchronous, 9-week "lunch and learn" series of non-credit professional development opportunities for colleagues at NCSA. About 40 individuals participated in that online training, and one of them came to the next in-person facilitator training. Together, the two trained facilitators from NCSA repeated the online seminar series the following fall, and 4 of the participants they trained came for the final in-person "train the trainers" workshop during summer 2023. With six trained facilitators on campus, the UIUC cohort contacted their central Human Resources department about making the CyberAmbassadors training available more broadly. Ultimately, five additional volunteers from UIUC completed the first fully-virtual facilitator training in November 2023 – and they are developing and piloting the full communications, teamwork and leadership certificate program for faculty and staff at UIUC in spring 2024. The eleven facilitators at UIUC now include employees from NCSA, the information technology department, and human resources, and the experience on this campus illustrates the potential for scaling up the CyberAmbassadors training.

The "train the trainers" effort included in the pilot project was successful in meeting its goals of preparing volunteers to use the curriculum to offer their own trainings. However, the pilot did not anticipate the desire for ongoing support and professional development opportunities that emerged within the community of trained facilitators. In the last two years of the pilot project, the investigators organized periodic conference calls for interested facilitators, seeking input on the type of professional development or support that might be of interest. One repeated request was for additional credentialing opportunities

for CyberAmbassadors facilitators, beyond the "Trained Facilitator" status earned by completing the "train the trainers" experience. In consultation with the group of trained facilitators, the investigators developed a process for interested volunteers to be recognized as "Certified Facilitators" by demonstrating success providing training across the full program curriculum. The facilitator community determined that candidates should organize and lead a minimum of 4 hours of training from at least 3 different sessions, covering all three modules of the curriculum (Communications, Teamwork, Leadership). Candidates must also prepare a brief application outlining their facilitation experience; describing how they used participant feedback to improve their facilitation skills; and providing an example of how they customized the curriculum materials for a specific audience, context, etc. This process was tested and refined in the last year of the pilot, with almost a dozen trained facilitators earning certification so far – and several more actively pursuing "Certified Facilitator" status.

The community of trained facilitators have identified other projects of mutual interest, such as developing a peer-mentoring program to provide individual coaching and support to newly trained facilitators as they begin to lead their own training sessions. There is also significant interest in working to translate curriculum materials into Spanish in order to reach a broader audience; one facilitator from the University of Puerto Rico Mayaguez has experimented with delivering the training in Spanish while using the English-language curriculum materials. While that approach has worked reasonably well at UPRM, where students frequently encounter multilingual instruction, other institutions and communities could benefit from a full translation of the CyberAmbassadors materials and an *ad hoc* group of volunteers has formed to explore this project. Another team of facilitators has explored the creation of training videos that can be used to provide more diverse "example scenarios" as part of the CyberAmbassadors curriculum materials. These volunteers took on the role of actors to create a few videos depicting common scenarios experienced by the CI workforce, such as having a disciplinary researcher approach a CI Facilitator for help using a supercomputer. These videos were used as part of the Virtual Residency training experience, with participants watching the videos, talking through the scenarios, and offering feedback and ideas about how the CI professional in the scenario might respond. While participant feedback on the use of these videos was quite positive, creating them is time-intensive and more volunteers would be needed to move the project forward.

In order to grow our community of volunteer facilitators, we will need to establish support systems and identify individuals to help assess the interests and needs of our volunteers; organize community activities; develop additional professional development opportunities; and build a leadership structure that can help coordinate and sustain this volunteer community in the longer term. Many professional societies and disciplinary organizations rely on volunteers to lead committees, plan activities and conferences, and develop processes for welcoming and supporting new members. Examples within the CI community include CaRCC, PEARC, SigHPC, and the Campus Champions. Each of these groups offers opportunities for volunteers to engage at different levels, including growing into leadership roles that can bolster individual careers. Setting up these community structures and systems will require an initial investment, however.

Program Logistics and Administration

While the NSF proposal included funding for the investigators to create, test, evaluate and refine the curriculum, it did not anticipate the administrative and logistical challenges of conducting thousands of participant trainings and managing dozens of volunteer facilitators annually. For instance, demand for fully-online trainings soared during the pandemic and in response the investigators established a series of three, 3-hour workshops leading to the CyberAmbassadors certificate. Initially, the investigators were handling the logistics (advertising, registration, zoom setup, etc.) and conducting all of these online trainings themselves. Even as other volunteers were trained to help provide this online instruction, the

primary responsibility for managing logistics, tracking participants' progress towards the certificate, and setting up and hosting the zoom sessions continued to fall on the investigators.

In order to create a more sustainable process for managing the ongoing demand for online trainings, the investigators are transitioning responsibility for logistics to TBP, which is already using this curriculum as the core of its own professional development program. Tau Beta Pi is a non-profit that has offered free professional skills training programs for more than four decades, and has a staff member who can help manage logistics like matching facilitators to session requests; maintaining participation records; and ensuring that curriculum materials are available as needed. The online trainings that lead to the CyberAmbassadors certificate are one of the professional development opportunities that TBP advertises to its members, and ensuring these sessions are available to broad audiences is a natural extension of TBP's outreach and education missions. The CyberAmbassadors investigators have already begun to train staff at TBP in managing the logistics of these online trainings, with the goal of continuing to offer them 3-4 times a year with TBP managing advertising, participant registrations, attendance records, and issuing certificates. Tau Beta Pi will also be responsible for setting up and hosting the zoom meetings used for these trainings, and for recruiting and supporting the facilitators who offer the training.

Future Work

While this pilot project was very successful, there are many areas where additional work could be pursued. The investigators have recently submitted a follow-up proposal that focuses on the following goals:

1. Broadening the scope of the curriculum to include two additional modules: culturally-aware Mentoring, with a focus on helping mentees prepare for successful CI careers; and the Training of new facilitators to help the CI workforce strengthen their professional skills.

2. Expanding access to formal and informal training using the CyberAmbassadors materials by: developing a series of open-source textbooks to complement credit-bearing coursework; and developing a training management system to support scalable, sustainable non-credit certificate programs.

3. Growing the community of volunteer facilitators and fostering their ongoing professional development, leveraging the work of a short-term community manager to assess needs, build additional professional development opportunities, and establish volunteer leadership structures that will ensure the long-term success of the CyberAmbassadors facilitator community.

Investing in this additional work would help to make the CyberAmbassadors accessible to a global STEM audience in the longer-term. However, for now the investigators are focused on collaborating with TBP to finalize the sustainability plan from the original pilot proposal, which seeks to make the curriculum materials and training broadly available to STEM students and practitioners.

Acknowledgements

References

[1] A. Briliyanti, J. Rojewski, T. J. Van Nguyen, K. Luchini-Colbry, and D. Colbry, "The CyberAmbassador Training Program," in *Proceedings of the Practice and Experience in Advanced Research Computing on Rise of the Machines (learning)*, Chicago IL USA: ACM, Jul. 2019, pp. 1–6. doi: 10.1145/3332186.3332218.

[2] "About – carcc.org." Accessed: Apr. 02, 2022. [Online]. Available: https://carcc.org/about/

[3] H. Neeman *et al.*, "The Advanced Cyberinfrastructure Research and Education Facilitators Virtual Residency: Toward a National Cyberinfrastructure Workforce," in *Proceedings of the XSEDE16 Conference on Diversity, Big Data, and Science at Scale*, in XSEDE16. New York, NY, USA: ACM, 2016, p. 57:1-57:8. doi: 10.1145/2949550.2949584.

[4] A. Briliyanti, J. Rojewski, D. Colbry, and K. Colbry, "Training the Trainers: Preparing Facilitators to Provide Professional Development for Engineers and Scientists," presented at the 2022 ASEE Annual Conference & Exposition, Aug. 2022. Accessed: Dec. 19, 2023. [Online]. Available: https://strategy.asee.org/training-the-trainers-preparing-facilitators-to-provide-professional-development-for-engineers-and-scientists

[5] A. Briliyanti, J. Wilson Rojewski, K. Luchini-Colbry, and D. Colbry, "CyberAmbassadors: Results from Pilot Testing a New Professional Skills Curriculum," in *Practice and Experience in Advanced Research Computing*, in PEARC '20. New York, NY, USA: Association for Computing Machinery, Jul. 2020, pp. 379–385. doi: 10.1145/3311790.3396619.