T^3-CIDERS Train-the-Trainers: Strengthening CI Skills for Cybersecurity Research and Education through Iterative Improvements in Second Cohort

Wirawan Purwanto
Old Dominion University
wpurwant@odu.edu

Mohan Yang
Texas A&M University
mohanyang@tamu.edu

Peng Jiang
University of Nebraska Omaha
pjiang@unomaha.edu

Dorothy X. Parry
Old Dominion University
dparr005@odu.edu

Belle Li
Purdue University
li4808@purdue.edu

Kristin Herman
Millersville University
kristin.herman@millersville.edu

Nolan Lovett
Old Dominion University
nlove002@odu.edu

Shanan Chappell Moots
Old Dominion University
schappel@odu.edu

Masha Sosonkina
Old Dominion University
msosonki@odu.edu

Hongyi Wu
The University of Arizona
mhwu@arizona.edu

ABSTRACT

T^3-CIDERS is a multi-year train-the-trainer program that develops university faculty, researchers, and students as future trainers (FTs) that are equipped to integrate advanced cyberinfrastructure (CI) skills, including high-performance computing (HPC), machine learning, big data analytics, and parallel programming, into cybersecurity research and education. This paper describes the iterative redesign of T^3-CIDERS from its first cohort (2024) to its second cohort (2025–2026), motivated by systematic evidence collected through pre/post surveys, daily reflections, observations, and interviews. Challenges identified in Cohort 1, such as unequal participant preparedness, participant fatigue from a dense schedule, limited interactivity, and insufficient community building drove a set of evidence-based program improvements. For Cohort 2, the pre-training phase was substantially expanded to cover all six technical modules and a foundational pedagogy module. The in-person institute was restructured for more substantial interactivity and engagement, adopting a rhythm of mini-lectures, hands-on CI learning, guided discussions, and studio-based lesson development. Community-building activities were strengthened through social events during the institute, structured mentorship meetings, and a new community webinar series. Early findings from Cohort 2, drawing from reflections and direct feedback from the participants, show increased participation in the program beyond the institute, as well as confidence and eagerness to teach CI to others. This paper offers a reproducible model of iterative, evaluation-driven redesign for HPC education and train-the-trainer programs.

KEYWORDS

Cyberinfrastructure, Cybersecurity, Research, Train-the-trainer, Pedagogy, HPC, Parallel Computing, Big Data, Machine Learning, Non-degree Training, Hands-on

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page, along with the DOI information below. To copy otherwise, republish, post on servers or redistribute to lists requires prior specific permission from the first author.

© 2026 Journal of Computational Science Education
https://doi.org/10.22369/issn.2153-4136/17/2/5

1 INTRODUCTION

Cybersecurity is a rapidly expanding field, crucial not only in information technology but across our tech-driven world [15]. Cyberattacks have become increasingly common and sophisticated in today's digital landscape, sparing no individual or organization from potential threats [12, 13]. Cybersecurity research and practice increasingly depend on advanced cyberinfrastructure (CI) capabilities—encompassing big data analytics, artificial intelligence (AI), high-performance computing (HPC), and parallel computing—to detect threats, train large-scale models, and process massive datasets at speed. This escalating challenge is compounded by a critical shortage in the cybersecurity workforce. There is a shortage of 4–5 million cybersecurity professionals globally according a 2024 ISC2 study [3]. Despite the growing importance of these CI tools in the state-of-the-art cybersecurity research and practice, there has been a persistent and systemic gap existing between CI availability and CI readiness among the cybersecurity workforce. One notable example is that traditional cybersecurity curricula at many institutions do not incorporate meaningful training in these CI methods. Closing this gap requires not merely more training resources or events, but a scalable strategy for producing qualified trainers who can bring CI skills into their own academic communities.

T^3-CIDERS, short for "Train-The-Trainer Approach to Fostering CI- and Data-Enabled Research in CyberSecurity" [14], is a train-the-trainer program to increase the adoption of advanced cyberinfrastructure (CI) and data skills into the fabric of research and education in cybersecurity and cyber-related disciplines. Rather than training individual learners directly at scale, T^3-CIDERS trains cohorts of "future trainers" (FTs)—faculty, researchers, and students—who are then equipped and obligated to conduct locally tailored CI training at their own institutions. This multiplier effect positions each cohort as a *node* in a growing network of CI-competent cybersecurity educators. T^3-CIDERS promotes the acquisition and propagation of expertise in CI technologies such as HPC, big data analytics, and machine learning/AI among the participants and their respective communities. The program empowers them to conduct more effective cybersecurity research. It aims to develop trainers in a community of next-generation cybersecurity researchers and educators who are proficient in CI technologies.

This paper focuses on the iterative redesign of T^3-CIDERS between its first cohort (2024) and its second cohort (2025–2026). Following the model of evidence-based program improvement [1], the design team systematically collected evaluation data from Cohort 1, identified specific challenges and pain points, and translated them into concrete structural changes for Cohort 2. We describe both cohorts, detail the redesign decisions and their rationale, and present early evaluation findings from Cohort 2.

2 OVERVIEW OF THE T^3-CIDERS PROGRAM

2.1 Vision and Goal

The overarching goal of T^3-CIDERS is to accelerate state-of-the-art research and development in cybersecurity and cyber-related fields by (1) preparing competent trainers to broaden the utilization of advanced CI in these disciplines, and (2) fostering a CI-enabled cybersecurity research community of practice [10, 11]. As a train-the-trainer program, T^3-CIDERS is designed to be synergistic with the teaching and research activities of its participants. Over time, the accumulation of FT cohorts across institutions would produce a diverse, self-sustaining community of practice of CI-competent cybersecurity researchers and educators.

2.2 Target Audience

FTs are recruited from university faculty, researchers, students, and practitioners with backgrounds in cybersecurity and cyber-related fields. Basic computer programming proficiency is a prerequisite for joining the program. Having prior experience with CI topics (HPC, AI, etc.) is beneficial but not required, as the program provides foundational instructions in these areas. FTs are organized into "FT units" pairing one faculty or researcher with one or two students, to encourage collaborative lesson development and peer learning.

2.3 Program Structure

T^3-CIDERS engages FTs through a year-long program with six interconnected phases [10]:

- Phase 1 – Pre-training: A self-paced, virtual training providing CI skills baseline and foundational pedagogical concepts, enabling all FTs to enter the in-person institute with shared foundational knowledge.
- Phase 2 – Summer/Winter Institute: An intensive, in-person, multi-day training combining hands-on CI technical instruction with pedagogy and instructional design practice, culminating in FT teaching demonstrations.
- Phase 3 – Learning Engagement: Ongoing virtual meetups, research webinars, and peer learning activities sustained throughout the academic year.
- Phase 4 – Local Training: FT units are required to conduct locally tailored CI training at their home institutions, with support from the T^3-CIDERS team.
- Phase 5 – K-12 Outreach: Optional, encouraged activities to promote CI and cybersecurity awareness among K-12 students.
- Phase 6 – "Module-X": Community-driven development of new CI training modules addressing emerging research needs, informed by FT's and community's input.

The first two phases serve as a condensed "boot camp" to build CI and pedagogical competencies. The T^3-CIDERS program leverages the six hands-on CI modules [7] previouly developed within the "DeapSECURE" training project [2, 6, 8, 9]. The remaining phases represent the sustained outcomes: local dissemination, community growth, and curriculum expansion.

The T^3-CIDERS project is designed for multiple successive cohorts. Cohort 1 completed the 2024 Summer Institute at Old Dominion University (ODU). Cohort 2 completed the 2026 Winter Institute at the University of Arizona. A third hybrid cohort is being planned. Beyond the funded period, an online adaptation (T^3-Online) will open the program to the broader public as an open educational resource (OER).

3 COHORT 1 (YEAR 2024): DESIGN, IMPLEMENTATION, AND EVALUATION

The T3-CIDERS design team adapted the Successive Approximation Model (SAM) [1] as its guiding instructional design process, consisting of preparation, iterative design, and iterative development phases [10]. A distinctive feature of the design process was the use of AI-generated learner personas to inform inclusive design decisions in the absence of direct access to the first cohort of participants [5]. Beyond that, the design process also involved multiple rounds of content and context analyses, including task analyses and learning objective development.

3.1 Recruitment, Pre-training, and Summer Institute

The Cohort 1 call for participation was disseminated in Spring 2024 through Virginia's research computing professional network (MARIA—Mid-Atlantic Research Infrastructure Alliance), the Commonwealth Cyber Initiative, and cybersecurity researcher networks. A total of 20 FTs participated in the 2024 Summer Institute: 8 faculty and researchers and 12 students (graduate and undergraduate) [10]. Participants represented multiple states (New York, North Carolina, Texas, Virginia, and Washington), and a range of institution types. The majority of FTs indicated primary research or study areas in

cybersecurity, followed by AI/ML, computer science, data science, and electrical and computer engineering.

Pre-training was delivered in Spring 2024 as a four-week self-paced virtual course on Canvas, covering two DeapSECURE modules: *Introduction to HPC* and *Dealing with Big Data*—each with lecture materials, readings, case studies, and hands-on Jupyter notebook activities. The 2024 Summer Institute was held July 29–August 2 at ODU in Norfolk, Virginia. The five-day program covered CI technical topics (Machine Learning, Deep Learning, Cryptography, and Parallel Programming), foundations of education and instructional design, lesson planning studio sessions, expert panels (cybersecurity practitioners and K-12 educators), and a capstone teaching demonstration by each FT unit.

3.2 Post-Institute Local Training and Module-X

Following the Summer Institute, the team continued to engage FTs virtually through newsletters, announcements via Discord, and optional meetings with the team.

3.2.1 Local Training. Many of the FT units from Cohort 1 successfully delivered their local training activities following the Summer Institute attendance, as showcased in Table 1. The total number of impacted learners across all the local training events is conservatively estimated at about 75.

Table 1: Local training and outreach activities conducted by Cohort 1 FT units.

Event Description	Type	Date(s)	Num. Learners
CTRL+ALT+ELITE – Level Up Your Skills With the Command Line	High school outreach workshop	April 2025	16
Federated Learning hands-on lesson	Graduate course lab	April 2025	9
Generative AI Capture the Flag	Virtual contest	Unknown	Unknown
Introductory workshops on AI/ML	Hands-on workshops	November 2024	25
Transformer Model Architecture	Seminar	April 2025	Unknown
Intro to HPC & Intro to Machine Learning	Hands-on workshops	Fall 2024	Unknown
Tutorial on Linux Command Line	Video tutorial	Summer 2025	N/A

3.2.2 Module-X: Federated Learning. The "Module-X" component of T^3-CIDERS encourages FTs to develop and contribute additional training materials on emerging CI and/or cybersecurity topics. One of the FT units developed such a new module in close collaboration with the T^3-CIDERS team. After completing the core CI training during the 2024 Summer Institute, this FT group developed a small hands-on lab on the topic of *federated learning* (FL) and delivered this lab in a graduate-level machine learning class (Spring 2025). Afterwards, they generalized and extended their lab materials to create a hands-on introductory FL lesson. FL is a branch of privacy-preserving machine learning, which is well aligned with their research interests. FL enables collaborative model training across decentralized clients without sharing the raw data, making it highly relevant for privacy-sensitive cybersecurity applications. The module was designed as a scaffolded, hands-on workshop that balances conceptual understanding with practical experimentation. The module was developed over the Fall 2025 semester and refined into a deployable instructional unit, which was demonstrated during the second cohort's Winter Institute.

Instructional Design: The FL module follows a progressive structure, guiding learners from foundational concepts to more advanced topics. It begins with the core FL workflow, including local model training and server-side aggregation, and then introduces challenges such as data heterogeneity and system variability. Subsequent components explore optimization strategies and security considerations, enabling participants to understand both performance and robustness aspects of FL.

Hands-on Implementation: To support experiential learning, the FL module is implemented through Jupyter notebook-based exercises executed on a HPC platform. Participants interact with real training pipelines, modify configurations, and observe the impact of factors such as non-IID (independent and identically distributed) data and algorithmic choices on model convergence and accuracy.

3.3 Evaluation

T^3-CIDERS evaluation employed a mixed-methods design aligned with Kirkpatrick's Four-Level Evaluation approach [4] including pre-surveys, daily reflections, post-institute surveys, observations, and post-cohort interviews. Initial results from Cohort 1 pre/post surveys (20 and 16 respondents, respectively) showed encouraging improvements in FT self-assessed CI knowledge, motivation, and confidence to teach. Qualitative feedback from daily reflections highlighted participant enthusiasm and creative planning for local training activities. However, the design team's retrospective analysis, through review of planning documents, implementation records, and weekly meeting notes, along with deeper qualitative feedback from interviews surfaced a set of specific challenges that would guide the redesign for the next cohort:

- *Unequal Preparedness*: FTs arrived with widely varying CI backgrounds; pre-training (HPC + Big Data) did not fully bridge the gap for participants with minimal prior CI experience, especially for advanced topics at the Institute.
- *Fatigue and Pacing*: The dense five-day schedule with heavy lecture content led to participant fatigue and reduced content absorption, particularly in the second half of the week.
- *Limited Interactivity*: Content was often delivered in lecture format with insufficient time for discussion, peer learning, and active application. Studio sessions, while valuable, needed greater scaffolding.
- *Student Disengagement Post-Institute*: Nearly half of student FTs became disengaged after the Summer Institute, resulting in low participation in local teaching activities and ongoing learning engagements.
- *Insufficient Community Building*: Participants reported insufficient opportunities to build interpersonal connections and research networks during the Institute; community engagement post-Institute was limited.

- *Operational Bottlenecks*: Centralized team responsibilities, late announcements, and Discord platform underutilization created logistical friction. Lesson plan completion was deferred post-Institute, creating an ongoing "assignment burden".

4 COHORT 2 REDESIGN AND IMPLEMENTATION

The transition from Cohort 1 to Cohort 2 was guided by a set of evidence-based redesign principles: (1) responsive design—using Cohort 1 evaluation to inform meaningful improvements while avoiding wholesale program overhaul; (2) balancing depth and accessibility—expanding pre-training so the in-person institute can engage more deeply; (3) building sustainable trainer communities through mentorship and structured community platforms; and (4) operationalizing pedagogical improvements so that training design itself models best pedagogical practices.

4.1 Operational Improvements

Cohort 2 recruitment began significantly earlier, enabling wider outreach, a larger candidate pool, and a more deliberate selection process. The team employed a structured voting process among PIs to evaluate applicants, ultimately selecting 20 FTs from a large pool of candidates. Operationally, the team distributed responsibilities more explicitly through role specifications, and shifted primary community communication from Discord to email (which proved more reliable for participants). Centralized master planning documents and a shared Google Drive workspace improved coordination.

4.2 Pre-training Expansion

One of the most substantial structural changes for Cohort 2 was the significant expansion of the pre-training phase. Whereas Cohort 1 pre-training covered only two modules (HPC and Big Data) with full hands-on activities, Cohort 2 pre-training expanded to cover all six core DeapSECURE CI topics and added a dedicated pedagogy module, for an estimated total of approximately 16 hours of content. Table 2 summarizes the revised pre-training curriculum.

Table 2: Cohort 2 Pre-training Modules

Module	Topic	Type	Hours
1	Big Data (Jupyter, Pandas)	Lecture video*	1
	Jupyter & Pandas	Hands-on	4
2	HPC (Unix shell, SLURM)	Lecture video*	1
	Shell & SLURM job scheduler	Hands-on	4
3	Educational Foundation	Lecture video*	2
4	Machine Learning	Lecture video*	1
5	Neural Networks	Lecture video*	1
6	Cryptography	Lecture video*	1
7	Parallel Programming	Lecture video*	1

The rationale for this expansion was to ensure that all FTs arrive at the in-person Winter Institute with at least a conceptual familiarity with each CI topic, regardless of their background. Modules 1 and 2 retain full hands-on activities; Modules 4–7 provide lecture-based overview videos and carefully curated reading materials without the hands-on activities to avoid overwhelming participants before the institute, while still broadening their exposure. The new pedagogy module (Module 3) provides foundational concepts in instructional design and adult learning, enabling FTs to connect pedagogical theory to practice more readily during the institute's studio sessions. Complex readings and external platform materials used in Cohort 1 were removed or simplified. Each module includes reflection questions; FTs are asked to respond with brief video podcasts or written reflections, promoting engagement and metacognitive processing before the institute.

4.3 Winter Institute (2026): Redesign and Implementation

The T3-CIDERS Winter Institute (WI), held from January 5–9, 2026 at the University of Arizona, served as a central program for Cohort 2. Building on evaluation findings and observations from the inaugural 2024 Summer Institute, the 2026 WI was strategically redesigned to address key challenges, including uneven participant preparedness, limited engagement, and insufficient time for hands-on and instructional development activities. The key changes include: (1) moving lecture-based contents to the pre-training phase; (2) increased time for hands-on activities and lesson development; (3) increased social activities; and (4) reduction of the institute time from five to four days.

4.3.1 Strategic Shift to Asynchronous Pre-Training. A major modification was the relocation of all the technical lectures into the expanded pre-training phase. Compared to the 2024 Summer Institute, where lectures and hands-on activities were co-located during the event, the 2026 WI moved foundational instructions to an asynchronous format prior to the institute. Participants completed approximately 16 hours of pre-training, which included recorded lecture-based overviews of four additional core CI modules. By front-loading more contents in the expanded pre-training, participants arrived at the WI with a more consistent baseline of knowledge. This shift also allowed the institute to be shortened from five to four days without sacrificing quality. This strategy significantly reduced the need for lecture-heavy sessions during the institute and enabled a stronger focus on more interactive and high-impact learning activities, as well as FTs' own lesson development rather than broad content coverage.

4.3.2 On-Site Program Structure. With lectures largely moved to pre-training, the on-site institute adopted a refined daily structure that emphasized hands-on practice and pedagogical development (see Table 3 for the detailed timetable of the contents):

- *Morning sessions* were dedicated to intensive, hands-on technical CI training aligned with the four core CI modules now added into pre-training: machine learning, neural networks, cryptography (including homomorphic encryption), and parallel programming. Mini-lectures were added as a refresher on the key points, as well as guided discussions. Rather than introducing new concepts through lectures, these sessions focused on experiential learning, including tool usage, problem-solving, and guided exploration of CI workflows. This approach allowed participants to deepen their understanding through active engagement.

- *Afternoon sessions* shifted toward pedagogical training and instructional design. Participants were introduced to key teaching strategies through concise lectures, followed by collaborative discussions and structured "studio time." During these sessions, FT units worked to develop their own training materials using the provided templates, including learning objectives, instructional activities, and evaluation plans.

Table 3: Cohort 2 Winter Institute Contents

Category	Day 1	Day 2	Day 3	Day 4
CI discussion	Mini-lecture (tech hands-on orientation); Group discussions (CI application for research)			
CI hands-on	Machine learning	Neural networks	Cryptography	Parallel programming
Pedagogy lecture & hands-on	Education basic, objectives, proposal	Backward design; lesson planning; Module-X demo	Instructional design	Activity showcase (1)
Studio time	Training proposal	Lesson planning; evaluation plan	Activity design	Activity showcase (2)

A notable addition to the 2026 WI was the inclusion of a "Module-X" session, delivered by a former FT from the 2024 cohort. (The design and development of this module have been discussed in the previous section.) This FT presented the newly built federated learning module on Tuesday afternoon (day 2). Beyond its technical content, this new module also serves as a proof-of-concept for sustainable curriculum evolution, demonstrating how participants from earlier cohorts can contribute new modules back into the program. Overall, the Module-X development highlights T^3-CIDERS' emphasis on modular, participant-driven curriculum design and reinforces its goal of equipping future trainers with both technical depth and instructional capacity.

To reinforce progress and reduce post-institute workload, participants were required to produce incremental deliverables throughout the week. This ensured that by the conclusion of the institute, most FT units had developed substantial portions of their lesson plans, minimizing the need to complete assignments after returning to their home institutions.

4.3.3 Community Building and Engagement. To strengthen participant engagement and address challenges observed in the 2024 cohort, the 2026 WI emphasized collaborative and interactive learning throughout the program. Structured development time enabled participants to iteratively design and refine their training materials in the studio during afternoon sessions with real-time feedback, peer collaboration, and continuous instructional support. We design the pedagogical activities to increase student FT's engagement by encouraging them to take a lead role during lesson design and planning, teaching demonstrations, as well as post-institute local training. In addition, the 2026 institute incorporated more social and networking activities aimed at fostering a community of practice.

4.3.4 Transition to Local Implementation. The Winter Institute concluded with a transition from centralized training to decentralized implementation. Equipped with near-complete lesson plans and strengthened technical and pedagogical skills, participants were prepared to carry out local training activities at their home institutions.

Preliminary observations suggest that this redesigned structure enabled earlier and more effective deployment of local teaching activities compared to the previous cohort. This outcome aligns with the core objective of T3-CIDERS: to empower participants to act as trainers and disseminate CI knowledge within their own academic and research communities.

5 THE SECOND COHORT INITIAL EXPERIENCE (2025–2026)

5.1 Participant Recruitment and Selection

The strengthened recruitment effort for Cohort 2025 yielded a substantially larger and more competitive applicant pool than the inaugural cohort. A total of 42 individuals from 15 institutions applied, of whom 25 were faculty or staff and 17 were students. Following a structured review process in which the principal investigators evaluated and voted on the applications, acceptance offers were extended to 23 individuals. Only 20 were able to attend the Winter Institute. The cohort was organized into ten FT units, with pairing decisions made primarily based on home institution or geographic proximity to facilitate practical collaboration in lesson planning and local training delivery. Most units consist of two FTs; one unit has three members, and one is a single member. Six of the ten units include at least one student member.

5.2 Cohort Demographics and Institutional Profile

The 20 participating FTs represent a broad cross-section of academic roles. Among non-student FTs, seven hold research tenure-track faculty positions (including one professor, one associate professor, and five assistant professors), three are teaching faculty or lecturers in non-tenure-track roles, one is a postdoctoral associate, and two are staff members. The seven student FTs include four Ph.D. students, two M.S. students, and one undergraduate student. In terms of gender, 14 FTs identified as male, five as female, and one preferred not to answer.

From the academic disciplines standpoint, the majority of FTs (nine) are affiliated with computer science departments, with three from electrical and computer engineering, and the remainder drawn from information systems, applied mathematics, cybersecurity, and research computing services. Seven FTs indicated research interests spanning both AI (or a subfield of AI) and cybersecurity—reflecting a stronger alignment between participants' technical backgrounds and the program's core curriculum than was seen in the first cohort.

The ten home institutions span ten states: Arizona, California, Colorado, Hawaii, Iowa, Indiana, Massachusetts, Nebraska, Oregon, and Virginia (Figure 3). Six institutions carry an R1 doctoral research classification, two are R2, and two are classified as research colleges and universities. Eight are large public universities; two are private institutions, one small and one medium-sized. Three of the ten

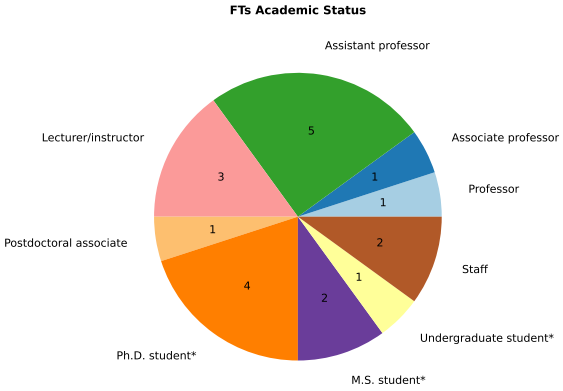


Figure 1: Academic status distribution of the 2025-2026 cohort.

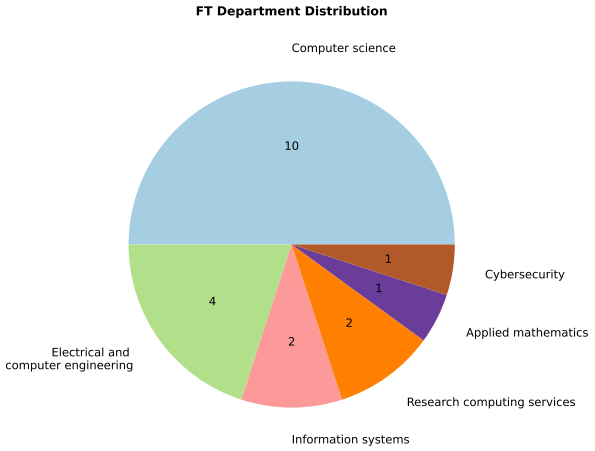


Figure 2: Academic departments indicated by the FTs (2025-2026 cohort).

institutions hold one or more minority-serving institution (MSI) designations — reflecting the program's commitment to broadening participation in CI-enabled cybersecurity research across diverse institutional contexts.

5.3 The 2026 Winter Institute

The 2026 Winter Institute was held at the University of Arizona in Tucson in January 2026, marking the first time the in-person institute was hosted outside of ODU. The four-day program reflected the structural and pedagogical redesigns described in Section 4: a compressed and better-paced schedule, a consistent daily rhythm alternating between technical and pedagogical content, and a deliberate emphasis on interactive discussion and hands-on activity over extended lecture. Each morning opened with a brief technical recap followed by guided discussion prompts that asked FTs to connect CI concepts to their own research or institutional contexts, before moving into hands-on lab work. Afternoons were devoted

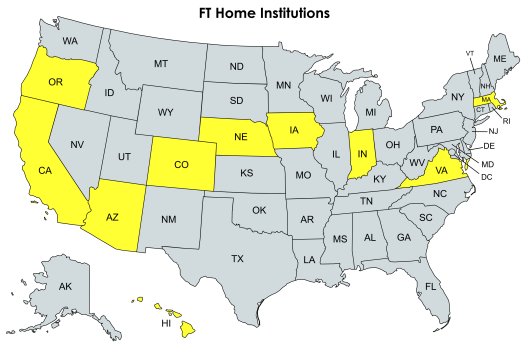


Figure 3: Geographical distribution of the Cohort 2 FTs' home institutions (created with mapchart.net).

to pedagogical sessions and structured studio time, during which FTs worked on their lesson plans using scaffolded templates — with the explicit goal of leaving the institute with substantially complete plans ready for local deployment. Social and community-building activities were woven throughout the four days, including: a welcome reception on the first evening, a cohort dinner on the fourth evening, organized tours of research facilities, and an optional hiking tour the day after the institute. These provided informal settings in which FTs could build personal connections alongside their technical and pedagogical work, thus facilitating a more cohesive and connected cohort that may extend the engagement beyond the institute.

5.4 Initial Reactions and Findings

Formal analysis of the pre- and post-institute survey data and interview transcripts for Cohort 2 is ongoing and will be reported comprehensively in a forthcoming publication. However, early indicators from participant reflections and unsolicited public feedback suggest a positive reception.

Several FTs shared their experiences on LinkedIn following the Winter Institute. Their posts point to three recurring themes: First, participants highlighted the value of the pedagogical content—specifically the theory-informed, evidence-based approach to instructional design—as something that offered new and practically applicable perspectives on curriculum development and course design. Second, they emphasized the utility of the T^3-CIDERS technical materials as resources directly transferable to their own CI- and AI-related courses. Third, participants consistently pointed to the professional networking and potential research collaboration opportunities afforded by the cohort experience as meaningful program outcomes in their own right.

These early signals are consistent with the program's intended impact at Kirkpatrick's first two levels—reaction and learning—and provide an encouraging precursor to the more systematic evaluation findings that are in process.

5.5 Remaining Cohort 2025 Activities

With the Winter Institute complete, FT units have moved into the local training and ongoing engagement phases of the cohort year. During this period, the T^3-CIDERS team is engaged in structured one-on-one mentorship meetings between FT units and project team members to provide individualized guidance for lesson plan refinement and local training preparation. As of the time of writing, five FT units have already delivered their local training activities—a notably higher early completion rate compared to Cohort 2024, which the project team attributes in large part to the redesigned studio sessions that enabled FTs to leave the institute with more fully developed lesson plans. The remaining units have confirmed plans for training delivery in the near term.

On the community engagement front, the inaugural T^3-CIDERS community webinar (April 1, 2026) drew participation from both cohort members and external attendees. Subsequent webinars are planned, with upcoming sessions to feature presentations by cohort members themselves—both deepening FTs' experience as presenters and extending the program's reach to a growing external audience. These activities collectively represent the ongoing learning engagement phase that sustains community momentum between the intensive institute experience and the longer-term community of practice that T^3-CIDERS aims to cultivate.

6 T^3-ONLINE: TOWARD A SCALABLE TRAIN-THE-TRAINER

The first two cohorts of T^3-CIDERS have demonstrated that an intensive, in-person train-the-trainer model can effectively build CI competencies and seed a community of practice. However, the cohort-based, in-person format inherently constrains program reach: each institute accommodates roughly twenty FTs, requires substantial travel and hosting resources, and is bounded by the institutional and regional networks through which recruitment is conducted. Building on the lessons learned from two in-person cohorts, the T^3-CIDERS team is developing an asynchronous, self-paced online adaptation of the program, known as "T^3-Online", to be released publicly as an Open Educational Resource (OER), thus extending the program's reach to faculty, researchers, students, industry practitioners, K-12 educators, and international participants who cannot be part of the in-person cohorts.

6.1 Design and Implementation of T^3-Online

The design of T^3-Online follows the same SAM-based iterative process used for the in-person program (see Fig. 4), proceeding through preparation, iterative design, and iterative development phases. The preparation phase draws directly on the rich evaluation dataset accumulated across Cohorts 1 and 2—demographic profiles, prior-experience data, and identified pain points—to construct empirically grounded learner personas and inform content chunking, cognitive load management, and scaffolding strategies suited to asynchronous delivery. The Cohort 2 pre-training curriculum and the federated learning Module-X serve as the primary content foundation, with materials re-mediated for self-paced formats where needed. Through its stages of development, the T^3-Online materials will be advanced from the *alpha* stage, to *beta*, and finally to *gold*.

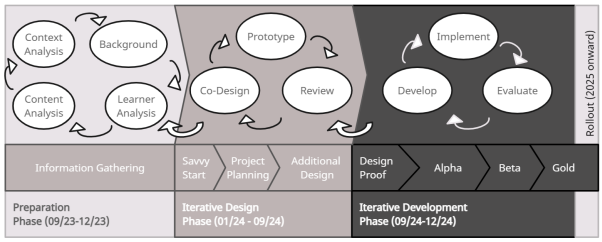


Figure 4: The iterative design and development process of T^3-CIDERS, which is roughly subdivided into three major phases following the Sucessive Approximation Method (SAM): Preparation, iterative design, and iterative development. T^3-Online will follow the same pattern, building upon the experiences of T^3-CIDERS cohorts.

The planned module structure follows a consistent architecture: short video lectures introducing core concepts; embedded or linked Jupyter notebooks, or access to an HPC sandbox environment for hands-on practice; self-check quizzes for formative assessment; reflection prompts (text or video) modeled on the Cohort 2's metacognitive activities; downloadable lesson-plan templates that learners progressively complete throughout the program; and a capstone teaching-demonstration submission that mirrors the culminating activity of the in-person institute.

Pedagogical scaffolding from the Cohort 2 redesign will be carried forward and adapted. The in-person cohort daily rhythm of mini-lectures, guided discussions, and extended studio time becomes a sequence of recorded mini-lectures with embedded discussion prompts, threaded discussion forums for asynchronous peer exchange, structured studio activities completed independently or in self-organized FT units, and scheduled live "office hours" providing synchronous touchpoints with the project team without requiring synchronous attendance from all learners.

6.2 Cohort 3: A Hybrid Pilot of T^3-Online

Cohort 3 will be conducted as a hybrid pilot that simultaneously serves two purposes: it delivers the train-the-trainer experience to a new group of FTs, and it provides the formative evaluation needed to advance T^3-Online from *beta* to the final *gold* stage.

The hybrid Cohort 3 experience will comprise three phases: (1) *Pre-institute phase*: FTs complete the full *beta* version of T^3-Online asynchronously over a defined window prior to the in-person event. (2) *Local-prep phase*: FT units draft lesson plans and training materials using T^3-Online's *beta* templates, with virtual mentorship checkpoints from the project team. (3) *In-person phase*: a condensed two-day institute focused almost entirely on FT teaching demonstrations, peer feedback, lesson-plan refinement, and community-building, rather than on content delivery.

The compression of the in-person institute from four days (Cohort 2) to two days is justified by the front-loading of technical and pedagogical contents into the online program. The remaining in-person time is reserved for the highest-bandwidth activities: live teaching practice, peer feedback, networking, and mentorship,

which Cohort 1 and 2 evaluation consistently identified as the most valuable elements of the program.

6.3 Rollout of T^3-Online

At the conclusion of the project's current funding period by U.S. National Science Foundation, T^3-Online will be released publicly as an Open Educational Resource, freely accessible to the cybersecurity and broader CI education communities. Web-based delivery is intended to maximize dissemination. Sustainability beyond the grant period will depend in part on identifying institutionally-supported personnel to maintain content currency and to facilitate periodic Module-X additions contributed by the growing FT alumni community.

7 CONCLUSION

T^3-CIDERS demonstrates that a rigorous, evaluation-driven approach to train-the-trainer program design can meaningfully advance the adoption of advanced cyberinfrastructure skills in cybersecurity research and education. Across its first two cohorts, the program has prepared forty future trainers drawn from diverse institutions nationwide, producing a growing body of locally tailored CI training activities that have collectively reached nearly two hundred learners at their home institutions. The program's core commitment to iterative improvement is demonstrated by translating the challenges identified from the first cohort into concrete redesigns of the pre-training curriculum, the in-person institute structure, the pedagogical approach, and the community engagement strategy. Early indicators from Cohort 2 suggest stronger pre-institute readiness, higher post-institute engagement with local training activities, and greater participant enthusiasm for teaching CI to others. The effort toward building a community-of-practice is also beginning to take shape, as cross-cohort connections form, a Module-X contribution, and a new webinar series opens the program to participants beyond enrolled cohorts. Looking ahead, the development of T^3-Online as an open educational resource will extend the program's reach to faculty, researchers, students, and practitioners beyond the current project funding's lifetime. The upcoming hybrid Cohort 3 model ensures that the online adaptation is validated against real learners before the public release. Together, these efforts constitute a scalable, reproducible, and community-sustained model for closing the CI skills gap in cybersecurity—one trainer, one institution, and one cohort at a time.

ACKNOWLEDGMENTS

The T^3-CIDERS program is collaboratively developed and delivered by Old Dominion University (ODU), the University of Arizona, the University of Nebraska Omaha, and Texas A&M University, with funding from the U.S. National Science Foundation CyberTraining program, grants #2320998 and 2320999. The authors graciously acknowledge the support from the University of Arizona for hosting the 2026 Winter Institute, and ODU Research and Cloud Computing group for the use of their Wahab HPC cluster for conducting the CI training activities. The Wahab cluster is supported in part by National Science Foundation's grant CNS-1828593, "MRI Acquisition: A Reconfigurable Computing Infrastructure Enabling Interdisciplinary and Collaborative Research in Hampton Roads". We also gratefully acknowledge the contributions of our teaching assistants to the success of this program: Jiawei Chen, Chun-lin Huang, Ted Birkland, and Junyi Jiang. Generative AI (Claude) has been used to synthesize the initial draft of the paper based on outlines, detailed notes, and other documents (which are not AI-generated) provided by the authors. The process is heavily constrained to produce texts that are grounded on these input materials. The generated texts have been edited and reviewed by the authors to ensure that this paper accurately represent the actual work of the authors.

REFERENCES

[1] Michael Allen and Richard Sites. 2012. *Leaving ADDIE for SAM: An agile model for developing the best learning experiences.* Association for Talent Development.

[2] Bahador Dodge, Jacob Strother, Rosby Asiamah, Karina Arcaute, Dr. Wirawan Purwanto, Dr. Masha Sosonkina, and Dr. Hongyi Wu. 2022. DeapSECURE Computational Training for Cybersecurity: Third Year Improvements and Impacts. http://www.modsimworld.org/papers/2022/MSVSCC_2022_InfrastructureSecurityMilitary.pdf

[3] ISC2. 2024. The State of the Cybersecurity Workforce. ISC2 Insights. https://www.isc2.org/Insights/2024/10/Cybersecurity-Workforce-INSIGHTS-October-2024 Accessed 2026-05-18.

[4] James D Kirkpatrick and Wendy Kayser Kirkpatrick. 2016. *Kirkpatrick's Four Levels of Training Evaluation.* Association for Talent Development.

[5] Nolan Lovett, Mohan Yang, Kristin Herman, Belle Li, Masha Sosonkina, Wirawan Purwanto, Peng Jiang, and Michael Hongyi Wu. 2025. Leveraging Large Language Models to Create Learner Personas for Training Design. *The Journal of Applied Instructional Design* 14, 3 (2025). doi:10.59668/2223.22718

[6] Wirawan Purwanto, Bahador Dodge, Karina Arcaute, Masha Sosonkina, and Hongyi Wu. 2024. DeapSECURE Computational Training for Cybersecurity Students: Progress Toward Widespread Community Adoption. *The Journal of Computational Science Education* 15 (2024), 2–9. Issue 1. https://doi.org/10.22369/issn.2153-4136/15/1/1

[7] Wirawan Purwanto, Issakar Doude, Yuming He, Jewel Ossom, Qiao Zhang, Liwuan Zhu, Jacob Strother, Rosby Asiamah, Bahador Dodge, Orion Cohen, Jiawei Chen, Chunyu Hu, Dorothy Parry, Peng Jiang, Masha Sosonkina, and Hongyi Wu. 2024. DeapSECURE Lesson Modules. https://deapsecure.gitlab.io/lessons/

[8] Wirawan Purwanto, Yuming He, Jewel Ossom, Qiao Zhang, Liuwan Zhu, Karina Arcaute, Masha Sosonkina, and Hongyi Wu. 2021. DeapSECURE Computational Training for Cybersecurity Students: Improvements, Mid-Stage Evaluation, and Lessons Learned. *The Journal of Computational Science Education* 12 (2021). Issue 2. https://doi.org/10.22369/issn.2153-4136/12/2/1

[9] Wirawan Purwanto, Hongyi Wu, Masha Sosonkina, and Karina Arcaute. 2019. DeapSECURE: Empowering Students for Data- and Compute-Intensive Research in Cybersecurity through Training. In *Proceedings of the Practice and Experience in Advanced Research Computing on Rise of the Machines (learning)* (Chicago, IL, USA) *(PEARC '19)*. ACM, New York, NY, USA, Article 81, 8 pages. doi:10.1145/3332186.3332247

[10] Wirawan Purwanto, Mohan Yang, Peng Jiang, Shanan Chappell Moots, Masha Sosonkina, and Hongyi Wu. 2025. T3-CIDERS: Train-the-Trainer and Community Building to Increase Cyberinfrastructure Adoption in Cybersecurity Research and Education. In *Proceedings of the Practice and Experience in Advanced Research Computing 2025: The Power of Collaboration* (Columbus, OH, USA) *(PEARC '25)*. ACM, New York, NY, USA, Article 21, 9 pages. doi:10.1145/3708035.3736021

[11] Wirawan Purwanto, Mohan Yang, Peng Jiang, Masha Sosonkina, and Hongyi Wu. 2025. T3-CIDERS: Fostering a Community of Practice in CI- and Data-Enabled Cybersecurity Research Through a Train-the-Trainer Program. *The Journal of Computational Science Education* 16, 1 (2025), 16–19. doi:10.22369/issn.2153-4136/16/1/4

[12] M. F. Safitra, M. Lubis, and H. Fakhrurroja. 2023. Counterattacking cyber threats: A framework for the future of cybersecurity. *Sustainability* 15, 18 (2023), 1–32. doi:10.3390/su151813369

[13] K. L. Snider, R. Shandler, S. Zandani, and D. Canetti. 2021. Cyberattacks, cyber threats, and attitudes toward cybersecurity policies. *Journal of Cybersecurity* 7, 1 (2021), 1–11. doi:10.1093/cybsec/tyab019

[14] T3-CIDERS Team. 2025. *T3-CIDERS Project Website.* Retrieved 2025-05-18 from https://sites.wp.odu.edu/t3-ciders/

[15] W.J. Triplett. 2023. Addressing Cybersecurity Challenges in Education. *International Journal of STEM Education for Sustainability* 3, 1 (2023), 47–67. doi:10.52889/ijses.v3i1.132