Strategies for Extending Cyber Training to Young Adults: Engaging the Future Cyberinfrastructure Workforce

Texas A&M High Performance Research Computing, College Station, TX 77843

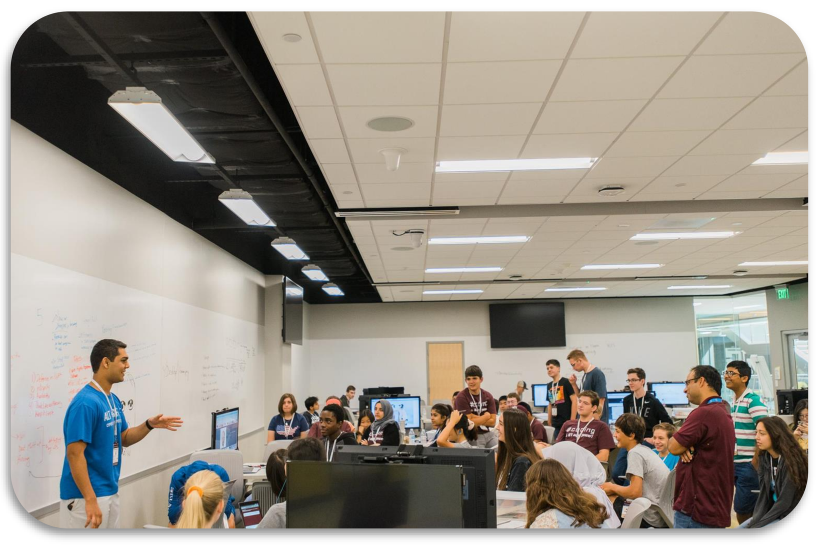
Overview

Identifying High-Impact Areas of Education:
Texas A&M High Performance Research Computing services thousands of researchers across the Texas A&M System. In this service, we have identified areas of computing skill and comprehension that would benefit many researchers, both new and experienced.

These areas include:
- Fluency in basic Unix/Linux operating system usage, especially in a non-GUI setting
- Experience with fundamental programming concepts, such as loops and data elements
- Experience with machine learning and its applications to real-world scenarios
- Introduction to parallelism and how to use parallelism to benefit from modern HPC resources
- Fundamental comprehension of cybersecurity implementation and practices

Multi-disciplinary training sessions provide opportunities to extend collaborations between HPC sites, information technology teams, domain-specific laboratories, and Campus Programs for Minors.
Thus, we sought to create an educational experience that:
1. Addresses the above *areas of computing skill and comprehension*
2. Targets new and upcoming members of the research community
3. Captures the attention of attendees through interactive activities and unique experiences

Learning Objectives



Introductory Level
1. Comprehension of Unix/Linux text-based interfaces
2. Ability to program in at least one high-level language
3. Understanding proper programming practices
4. Skills to utilize common tools in industry, such as Python
5. Enhanced motivation to pursue a career in STEM

Intermediate Level
1. Approaches to solving problems in cybersecurity
2. Using artificial intelligence for automation of processes
3. Applying virtual reality to create innovative methods of education.
4. Greater interest in pursuing careers in cybersecurity, computing and related STEM fields
5. Understanding of interfacing hardware with software

Recruitment & Attendees

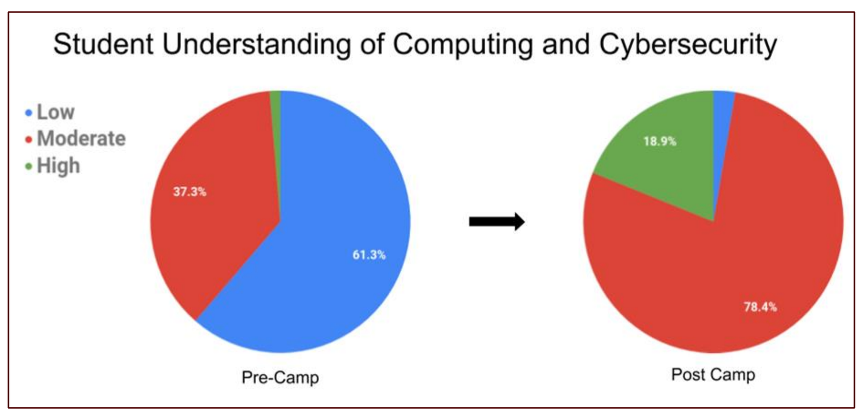
Target Audience:
In order to have the greatest effect, we targeted a diverse selection of high school students from many backgrounds who each expressed interest in careers related to computing, engineering, science, or research. The entry experience level was minimal in order to reach those who may otherwise lack the opportunity to gain cyberinfrastructure training during this influential period of life.

Working with Minors:
Hosting young students had challenges including but not limited to:
- Qualified supervision: background checks, child safety training, good student-to-staff ratio
- Student attention: experienced staff taught lectures, logistics to keep students constantly occupied
- Encouraging learning: activities designed to spark curiosity, lessons connected to real-world material

The SCA has achieved recognition by oversight groups for addressing and excelling in these aspects.

Outcomes

Integration:
Since 2017, SCA has welcomed over 220 participants, the majority from groups traditionally underrepresented in computing. Participants have indicated an increased attitude toward STEM with overall gains in knowledge of STEM careers. In 2019, an interest development found that 100% of SCA participants successfully transitioned from a group with "lower interest" in computing to groups with moderate or higher interests in computing. Students also demonstrated gains in programming ability, with some having successfully applied to Texas A&M, Duke and UT Austin.



Suggested Curriculum

Foundations of Computing

Students should understand how to access computational resources and complete basic tasks. These tasks are listed below:
- Navigate a Unix/Linux system without a graphical interface
- Manipulate files, directories, and processes
- Access remote systems using Secure Shell: *ssh*
- Automate tasks using scripts and scheduled jobs

Introduction to Programming

Students should have an understanding of basic programming practices and concepts. The practices and concepts are as follows:
- Proper syntax and naming convention
- Clear and concise comments for program functions

Harnessing HPC

Students were introduced to the field of high-performance computing and its significance to areas of research and other activities that require large amounts of computational resources by:
- Building small-scale computing clusters from Raspberry Pi's
- Learning how a cluster communicates internally and externally
- Identifying applications of HPC

Experiential Learning via Field Trips

Facility tours connect students' lessons to potential career paths.
- Data enter: connect cloud computing to physical machines
- Engineering facilities: witness the design process of real products
- Research laboratories: explore the roots of discovery and innovation

Python and Scripting

Students were introduced to the ubiquitous language of Python, and related programming practices. They were tasked with problem-solution sets structured like games to maintain attention. Students learned to:
- Interface Python with Raspberry Pi hardware and related peripherals
- Translate common language into Python syntax
- Build upon previously learned topics to solve present problems

Machine and Deep Learning

Through the use of image recognition algorithms built upon simple machine learning concepts that are made more complex throughout the lesson, students are taught:
- Ideas behind how machine learning is implemented
- Applications of machine and deep learning practices
- Use tools such as Power AI to train and build applications

Lessons in Cybersecurity

Access to powerful computing resources and systems containing private data requires a functional knowledge of good cybersecurity practices. Students are taught an overview of cybersecurity as it pertain to HPC:
- The Attacker Model: Who? Why? How?
- Compliance with Export Control Laws
- How SSH and encryption contribute to a secure system
- Modern implementations of Authentication and Trust

Cryptography

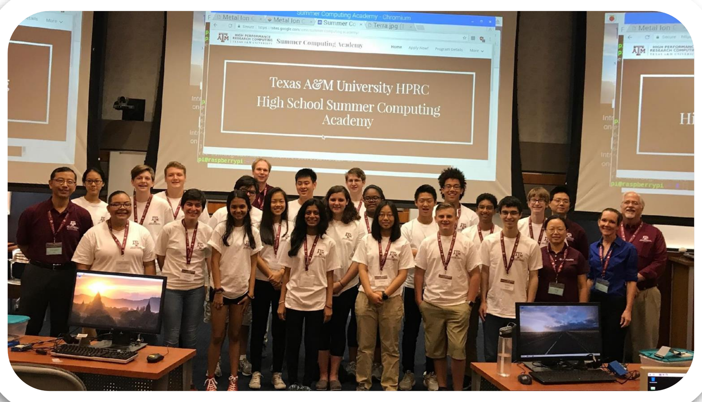
The concept of cryptography was taught to students with heavy emphasis on real-world applications. They were taught to solve problem sets with a wide range of solutions. Students learned:
- Encryption and decryption of data
- To identify methods of finding solutions in the context of cryptography
- The importance of cryptography in security

Applications of Virtual Reality

Students were introduced to the application of virtual reality technology in various contexts, such as:
- Data center training for cybersecurity professionals in data center management and security
- Mars planet and space station simulations for training and informing astronauts

References

- Chakravorty et al. 2018. Evaluating Active Learning Approaches for Teaching Intermediate Programming at an Early Undergraduate Level. In *Journal of Computational Science Education* (2018) (to appear).
- Jinsil Hwaryoung Seo, Michael Bruner, Austin Payne, Nathan Gober, Donald "Rick" McMullen, and Dhruva K. Chakravorty. 2018. Using Virtual Reality to Enforce Principles of Cybersecurity. Journal of Computational Science Education (Nov 2018) (to appear).
- NSF Award #1730695, CiSE-ProS
- 2016-2019 Short Course Material, TAMU HPRC



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