CYBERSECURITY PEDAGOGY & PRACTICE JOURNAL

Volume 4, No. 1
April 2025
ISSN: 2832-1006

In this issue:

4. **Education Impact on Trust in Election Technology & Security: Research Proposal**
Garry White, Texas State University
Ju Long, Texas State University

13. **Cybersecurity Apprenticeships: Case-Study of a Four-Year Youth Apprenticeship Program**
Paul Wagner, University of Arizona
Cathleen Barton, Cathleen Barton Consulting

24. ***Teaching Case***
Reshaping Cybersecurity Ethics Education: Evaluating a Posthumanist Pedagogy Using Human/AI Co-Generated Case Studies
Ryan Straight, University of Arizona
Jonathan Lowery, University of Arizona
David Poehlman, University of Arizona
Waamene Yowika, University of Arizona

35. **A Pivotal Progression of SEC's Cybersecurity Disclosure Requirements**
Yining Chen, Western Kentucky University
Divine Lokuku, Western Kentucky University
Tong Wu, Western Kentucky University

The **Cybersecurity Pedagogy and Practice Journal** (**CPPJ**) is a double-blind peer-reviewed academic journal published by **ISCAP** (Information Systems and Computing Academic Professionals). Publishing frequency is two times per year. The first year of publication was 2022.

CPPJ is published online (https://cppj.info). Our sister publication, the proceedings of the ISCAP Conference (https://proc.iscap.info) features all papers, panels, workshops, and presentations from the conference.

The journal acceptance review process involves a minimum of three double-blind peer reviews, where both the reviewer is not aware of the identities of the authors and the authors are not aware of the identities of the reviewers. The initial reviews happen before the ISCAP conference. At that point, papers are divided into award papers (top 15%), and other accepted proceedings papers. The other accepted proceedings papers are subjected to a second round of blind peer review to establish whether they will be accepted to the journal or not. Those papers that are deemed of sufficient quality are accepted for publication in the CPPJ journal.

While the primary path to journal publication is through the ISCAP conference, CPPJ does accept direct submissions at https://iscap.us/papers. Direct submissions are subjected to a double-blind peer review process, where reviewers do not know the names and affiliations of paper authors, and paper authors do not know the names and affiliations of reviewers. All submissions (articles, teaching tips, and teaching cases & notes) to the journal will be refereed by a rigorous evaluation process involving at least three blind reviews by qualified academic, industrial, or governmental computing professionals. Submissions will be judged not only on the suitability of the content but also on the readability and clarity of the prose.

Currently, the acceptance rate for the journal is under 35%.

Questions should be addressed to the editor at editorcppj@iscap.us or the publisher at publisher@iscap.us. Special thanks to members of ISCAP who perform the editorial and review processes for CPPJ.

2025 ISCAP Board of Directors

Amy Connolly James Madison University President	Michael Smith Georgia Institute of Technology Vice President	Jeff Cummings Univ of NC Wilmington Past President
David Firth University of Montana Director	Mark Frydenberg Bentley University Director/Secretary	David Gomillion Texas A&M University Director
Leigh Mutchler James Madison University Director	RJ Podeschi Millikin University Director/Treasurer	Jeffry Babb West Texas A&M University Director/Curricular Matters
Eric Breimer Siena College Director/2024 Conf Chair	Tom Janicki Univ of NC Wilmington Director/Meeting Planner	Xihui "Paul" Zhang University of North Alabama Director/JISE Editor

Copyright ©2025 by Information Systems and Computing Academic Professionals (ISCAP). Permission to make digital or hard copies of all or part of this journal for personal or classroom use is granted without fee provided that the copies are not made or distributed for profit or commercial use. All copies must bear this notice and full citation. Permission from the Editor is required to post to servers, redistribute to lists, or utilize in a for-profit or commercial use. Permission requests should be sent to editorcppj@iscap.us.

CYBERSECURITY PEDAGOGY AND PRACTICE JOURNAL

Editors

Anthony Serapiglia
Co-Editor
Saint Vincent College

Jeffrey Cummings
Co-Editor
University of North Carolina Wilmington

Thomas Janicki
Publisher
University of North Carolina Wilmington

2025 Review Board

Cheryl Beauchamp
Regent University

Ulku Clark
Univ of NC Wilmington

Peter Draus
Robert Morris University

Nick Giacobe
Penn State University

Mike Hills
Penn State University

Jeff Landry
Univ of South Alabama

Li-Jen Lester
Sam Houston State Univ

Jim Marquardson
Robert Morris University

Stan Mierzwa
Kean University

Etezady Nooredin
University of New Mexico

Ron Pike
Cal Poly Pomona

RJ Podeschi
Milliken University

Samuel Sambasivam
Woodbury University

Kevin Slonka
Saint Francis University

Geoff Stoker
Univ of NC Wilmington

Paul Wagner
University of Arizona

Ping Wang
Robert Morris University

Tobi West
Coastline College

Johnathan Yerby
Mercer University

Cybersecurity Apprenticeships: Case-Study of a Four-Year Youth Apprenticeship Program

Paul Wagner
paulewagner@arizona.edu
Department Cyber, Intelligence, and Information Operations
University of Arizona
Tucson, Arizona 85747, USA

Cathleen Barton
cbarton673@gmail.com
Cathleen Barton Consulting
Scottsdale, Arizona

Abstract

The United States is facing a persistent cybersecurity workforce shortage, which has significant implications for national security and economic growth. Innovative solutions are required to address this challenge. Youth apprenticeships represent a possible solution for filling talent needs; preparing young people for high-growth careers; building more consistent talent pipelines; creating connections between secondary and postsecondary education institutions, workforce development systems, and community-based organizations; and solving workforce needs. This paper provides a case study of a youth apprenticeship program in cybersecurity. This four-year competency-based program is designed for Arizona high school students and represents a collaboration of an Arizona high school, Phoenix Coding Academy; an industry partner, Kudelski Security; and a non-profit intermediary, the Center for the Future of Arizona (CFA). The program builds upon Kudelski's Switzerland based IT apprenticeship model, adapting it to the U.S. context and incorporating industry partnerships and post-secondary education institutions. This case-study evaluates the effectiveness of the youth apprenticeship program in developing cybersecurity talent, with a focus on its impact on student outcomes, career readiness, and employer satisfaction. Program outcomes include reduced student debt, increased job readiness for entry-level cybersecurity professionals, and contributing to a more diverse and skilled cybersecurity workforce in Arizona and beyond.

Keywords: Youth Apprenticeship, Cybersecurity Education, Workforce Development, Competency-Based Learning, Industry Partnerships

Recommended Citation: Wagner, P., Barton, C., (2025). Cybersecurity Apprenticeships: Case Study of a Four-Year Youth Apprenticeship Program. *Cybersecurity Pedagogy and Practice Journal.* v4, n1, pp 13-23. DOI# https://doi.org/10.62273/UQKC5113

©2025 ISCAP (Information Systems and Computing Academic Professionals)

Cybersecurity Apprenticeships: Case-Study of a Four-Year Youth Apprenticeship Program

Paul Wagner and Cathleen Barton

1. INTRODUCTION

The cybersecurity workforce shortage continues to be a concern with over 450,000 unfilled positions within the United States (Cyberseek, 2024) and nearly four million globally (ISC2, 2023). Additionally, the cybersecurity threat continues to grow in sophistication, frequency, and scale increasing stress on the cybersecurity workforce which leads to high employee turnover. White and Bunce (2023) estimates that nearly 51% of cybersecurity professionals will leave the field due to stressors like staffing and resource limitations, rising complexity of technology, remote work challenges, and compliance and regulatory pressures.

Compounding this problem is the increasing dissatisfaction of employers regarding the Knowledge, Skills, and Abilities (KSA) of cybersecurity graduates' ability to fulfill the required tasks of the organization. Ross and Duke (2018) stated, "employers are expressing increasing concern about the relevance of certain cybersecurity-related education programs in meeting the real needs of their organization," in a report to the President of the United States. Additionally, an ISACA report (2023) identified that only 28% of employers surveyed believed that recent cybersecurity graduates were well prepared to meet the cybersecurity challenges of the organization citing lack of technical and soft skills.

One option for addressing these concerns and the cybersecurity workforce gap is to increase youth apprenticeship opportunities for potential cybersecurity professionals to develop the necessary knowledge, skills, and abilities to perform the required tasks. This paper reviews general cybersecurity learning paths, cybersecurity apprenticeship programs, and government initiatives to promote cybersecurity apprenticeship programs. Further, it will provide a case-study of a four-year U.S.-based cybersecurity youth apprenticeship program. Finally, this paper outlines future work and initiatives in expanding or duplicating this program.

2. LITERATURE REVIEW

Cybersecurity Learning Paths

Cybersecurity education requires a holistic approach integrating formal, non-formal, and informal learning to develop the KSAs required to complete required tasks. Formal learning is intentional, organized, and structured; usually arranged by institutions; and guided by curriculum or another formal program (Ainsworth, 2010). Non-formal learning may or may not be intentional or arranged by an institution but is usually organized somehow. There is no form of credit granted by this form of education (Ainsworth, 2010). Non-formal learning can include attending camps, industry certifications, and internships. Informal learning is never organized or guided by a rigid curriculum and is often considered experiential and spontaneous (Ainsworth, 2010). Examples of informal learning include participation in clubs, competitions, conducting self-study, and attending conferences and industry events.

Wagner (2023) proposed in their CyberEducation-by-Design Framework that non-formal and informal learning could be integrated into formal learning to provide enhanced learning for secondary education students to prepare them for future training and education, military service, or beginning their career in the workforce (Figure 1). Although Wagner's framework focuses on secondary education; Formal, Non-Formal, and Informal learning opportunities can be found at any level of education or at various stages in an individual's career.

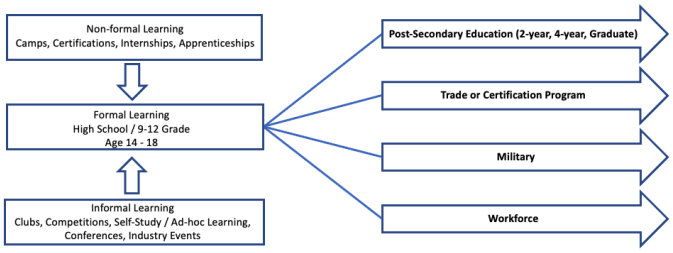


Figure 1 – CyberEducation-by-Design Framework (Wagner, 2023)

Apprenticeship Programs

This paper focuses on apprenticeship programs holistically before focusing on cybersecurity-

specific government initiatives and programs. Apprenticeship programs allow potential employees to gain, develop, and refine their cybersecurity skills while providing insight into the career field. They are considered a cost-effective approach to learning relevant academic, occupational, technical, and soft skills. Apprenticeships are unique in that they enhance the worker (supply) and employer (demand) side of the labor market (Lerman et al., 2020). Additionally, apprenticeship programs "improve the learning process (as students directly apply what they learn), encourage student engagement, increase incentives for students to perform well in academic courses, improve the match between workers' skills and labor market demands, encourage employers to upgrade their mix of jobs, and widen access to rewarding careers for workers who prefer learning by doing over traditional classroom and four-year college models." (Lerman et al., 2020) Further, 71% of individuals involved in apprenticeship programs felt that the programs led to better jobs due to increased salary, acquisition of skills, an expanded professional network, and more interesting work (Page et al., 2020).

The United States Department of Labor identifies six key characteristics of apprenticeships to differentiate this learning opportunity from internships. These are length, structure, mentorship, pay, credential, and college credit. Figure 2 outlines and describes these characteristics.

Apprenticeship
1. Length: 1-3 years
2. Structure: Structured training plan with focus mastering specific skills that an employ is typically looking to fill
3. Mentorship: Individualized training is provide overseen by an experienced mentor
4. Pay: Paid experience that can often lead to fu time employment
5. Credential: Often leads to an industry-recogniz credential
6. College Credit: Often granted; sometimes significant

Figure 2 – Apprenticeship Characteristics (Stoker, 2021)

Government Initiatives for Cybersecurity Apprenticeships

Cybersecurity apprenticeship programs are a subset of the overall apprenticeship programs previously discussed. Sponsors of these programs yield a significant return on investment in high employee productivity (highly skilled in unique roles), high employee retention (91% of apprentices retained employment nine months after program completion), and reduced recruiting costs (lower attrition) (CYAI, 2024). Apprenticeship programs have the potential to fill the increasing skills gaps in high-demand areas such as application development security, cloud security, risk management, threat intelligence, incident response, data privacy and security, compliance and controls, access management, health information security, and security strategy and governance. The projected five-year growth in these skill areas is outlined in Figure 3.

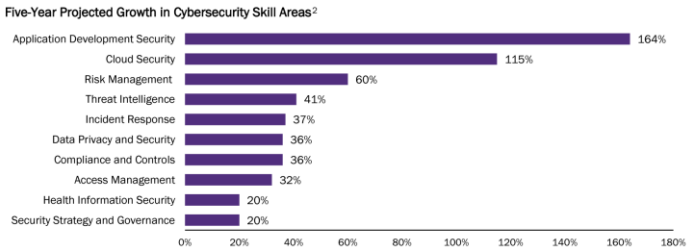


Figure 3 – Five-Year Projected Growth in Cybersecurity Skills Areas (CYAI, 2024)

Cybersecurity apprenticeships are becoming a growing initiative supported by the government. The National Institute of Science and Technology's (NIST) National Initiative for Cybersecurity Education (NICE) Cybersecurity Apprenticeship Program Finder was a tool developed to support future cybersecurity professionals through paid work experience and work-based learning,
classroom instruction, mentoring, and a nationally- or state-recognized credential upon completion of the program (NIST NICE, 2022).

Reviewing the opportunities compiled on the NICE Cybersecurity Apprenticeship Program Finder identifies 159 unique apprenticeship opportunities; however, there are multiple listings from organizations like Apprenti, Boeing, and Camden Dream Center Technology Training School (NICE, 2024). Of these, nearly 50% (77 opportunities) provide virtual apprenticeship programs (NICE, 2024).

This effort aligns with the Cybersecurity Apprenticeship Sprint led by the Department of

Labor, the White House, the U.S. Department of Commerce, and other federal agencies. The results of this 120-day initiative included:

- 194 cybersecurity registered apprenticeship programs approved or under development,
- Program sponsors added 120 cybersecurity-related occupations to pre-existing and newly registered apprenticeship programs,
- 7,000 apprentices hired,
- Major organizations like IBM, CompTIA, and the Department of Defense (DoD) expanding their programs and Boeing, Cisco Systems, McDonald's, Department of Veterans Affairs, and more launched new programs, and
- Over 2,000 organizations and career seekers expressed interest in learning more about the registered apprenticeship program (The White House, 2022).

3. KUDELSKI APPRENTICESHIP PROGRAM

Kudelski Apprenticeship Program

The Kudelski Group is headquartered in Cheseaux-Sur-Lausanne, Switzerland and is a world leader in digital security. Kudelski selected Phoenix, AZ as its second headquarters in 2016 which serves as the home for its cybersecurity business, Kudelski Security. Kudelski Security provides intelligent cybersecurity that addresses challenges through Managed Security Services (MSS), advisory, customized innovation, and technology consulting (Kudelski Security, 2024). Swiss-based companies see it as their obligation to prepare people for productive and meaningful employment with 30 percent of companies hiring student apprentices (NCEE, 2024). Similarly, Kudelski has utilized three- and four-year apprenticeships for more than twenty years and wanted to demonstrate the viability of youth apprenticeship as a model to develop high-tech talent in the U.S., despite high-tech apprenticeship being a relatively new model in the U.S., and for U.S.-based Kudelski employees. The Kudelski Group is also a signatory to a Memorandum of Understanding between the Swiss Confederation and the U.S. Department of Labor to develop apprenticeship programs in the U.S. Kudelski's Switzerland based IT apprenticeship program includes classroom education and instruction, and On-the-Job-Training (OJT) that provides hands-on application of the conceptual and theoretical aspects taught in the classroom. Kudelski sought to develop an apprenticeship model compatible with the U.S.'s secondary and post-secondary school system and with as much fidelity to the Swiss model as possible. It was also thought that increased utilization of youth apprenticeship could help address the problem of increasing student debt for higher education since apprentices are paid for their work and may also have the benefit of their sponsor company paying for their post-secondary education for further development of skills and expertise.

Partnerships and Planning

Kudelski relocated their Swiss apprenticeship manager to the U.S. in 2018 to work with the U.S.-based staff and to create and implement their apprenticeship strategy. Outreach to the Maricopa Community College District provided Kudelski with an introduction to The Center for the Future of Arizona (CFA), a possible partner to assist in the development of this new endeavor.

CFA is a nonprofit, nonpartisan organization with deep and ongoing work in education, workforce, and civic health with partners at local, state, and national levels including nonprofits, K-12 and higher education, community-based organizations, government, philanthropic, business, and industry. Arizona Pathways to Prosperity (APTP), a CFA impact initiative, is part of the National Pathways to Prosperity movement in collaboration with Jobs of the Future (JFF), the Harvard Graduate School of Education, states, and geographic regions. The National Pathways to Prosperity movement was informed in large part by the Swiss Apprenticeship system, and APTP's implementation was aligned with the Kudelski apprenticeship program. APTP supports educational attainment, creates future opportunities, and leads to upward economic mobility for all young Arizonans while supporting state and regional talent needs. APTP works with educational partners and industry to identify the careers, knowledge, skills, and degrees/credentials businesses need to grow and thrive.

Kudelski and CFA reviewed information on current youth apprenticeships in the U.S. during the development stages of the apprenticeship. Of particular interest and value was the CareerWise youth apprenticeship program, which was founded in 2016, launched its first cohort in 2017, and has seen more than 1,400 apprentices hired by more than 120 employers (CareerWise, 2024). Kudelski and CFA met with CareerWise Colorado leaders to learn from their experiences of launching a successful program which was a hybrid of the Swiss system with adaptations for local education systems, businesses, and industry needs. CareerWise Colorado's three-year apprenticeship model starts during the junior

year of high school, consistent with the Kudelski model in Switzerland and the desired U.S. model.

Meetings held with the Arizona Office of Apprenticeship identified the 4-year competency-based Junior Cybersecurity Analyst apprenticeship role. This role was designed to include the key elements of expert mentorship across the different technical content areas of the apprenticeship, working on projects individually and in teams, and providing the flexibility for Kudelski to incorporate company-specific needs and requirements.

Based on the best information on implementing high-tech youth apprenticeships in the U.S, and the Kudelski apprenticeships in Switzerland, determinations were made about core elements for high school partner selection and the work-based learning structure and hours. The resulting OJT training model included an average of 12 hours per week during their junior year (year one), 16 hours during senior year (year two), 16-20 hours during year three, and 20-24 hours during year four. Year four was typically the second year of post-secondary education. Students are expected to work approximately four hours per day, three to four days per week, from 1-5 pm during years one and two. Schedules are more flexible in years three and four based on apprentices' post-secondary school schedules. Additional hours and flexibility of schedules are supported during summer and school break periods.

Key selection characteristics for the school consisted of:

1) Districts and schools are open to working as a partner with the company and to schedule flexibility. Large enough student body to support desired number of apprentices.
- Big Picture: Commitment to excellence, set students up for success in school and work-based learning.
- Logistics: Accommodate school and business schedule (Monday-Friday; 8 am to 5 pm), course release/seat time, reasonable distance to travel from school to Kudelski.

2) Relevant academic and curriculum infrastructure and teacher support.
- The school has preexisting course curriculum, IT, CS, or cybersecurity ideally; Dual enrollment options.
- A partner teacher who teaches IT/computer science and is committed to serving as the point person to ensure students receive the necessary skills and knowledge in course work.

3) School and parental support to ensure student (apprentice) success in both school and apprenticeship. Most important during the first two years of the apprenticeship.
- Parental support as a critical element for a new model for work experience and maintaining solid academic performance.
- Transportation: Students' ability, with support from caregivers and school, to get to and from the work site.

4) Communication is key: Constant, open channels of communication.
- Ongoing communication on student assignments and progress/performance and opportunities for lead teachers to stay abreast of apprenticeship goals and support them as appropriate with classroom learning.
- Maintaining open communications between partners to respond to changes, issues.

These salient elements for partner selection and building on the core alignment of work-based learning as part of the school's mission:
- Relevant Coursework: Offering coursework in Information Technology (IT), Networking, Computer Science, Cybersecurity, and preferably having dual enrollment course options for students in technical, Mathematics, and English classes.
- Scheduling Flexibility: Ability to commit to allocating some student release time during the school day, to support the minimum of 12 and 16 OJT hours during their junior and senior secondary education years.
- Student Population Size: A large enough student body to support a reasonable number of interested student candidates that would apply for the apprenticeships.
- Student Attributes/Abilities: Students were not expected to have significant technical skills before beginning the apprenticeship. Interest in the field, curiosity, communication skills, and general knowledge and awareness of the IT and cybersecurity field were expected.
- Parent support for students/youth apprentices: Apprenticeship was a new model and required a significant commitment on the part of the student and their families. Approval by a parent or guardian was required for application.

Initially, nine high schools were identified for exploratory discussions based on the school

selection characteristics. Phoenix Coding Academy (PCA) was determined to provide the best opportunity for partnering and mutual success. PCA is a learning community that engages students in computer science pathways and innovative academic experiences that empower them to make confident decisions about their life's journey (PCA, 2024). PCA is a specialty high school and part of the Phoenix Union High School District (PXU), which consists of 24 schools, tens of thousands of students, and over 3,500 employees (PXU, 2024). PCA students are predominately Hispanic (59%) with over 70% of students eligible for free or reduced lunch (NCES, 2023).

PCA focuses on computer coding and multiple technology pathways leveraging inquiry-based instructional design. Academic courses are integrated offering a dynamic, student-centered educational experience and PCA students receive a full high school curriculum consisting of core academic classes, electives, and Career and Technical Education (CTE) classes. CTE pathways include software development (game, application, and web development), computer networking, and cybersecurity which leads to select industry certification, college dual enrollment, and preparation of students for post-secondary success.

Program Roles

PCA would provide technical instruction in networking and security during the first two years of the apprenticeship and meet three to four times per year to ensure complementarity of instruction with planned OJT. Further, PCA and Kudelski would support the development of individualized plans for apprentices to pursue post-secondary education in years three and four of the apprenticeship, based on the apprentices' interests and Kudelski's plans. CFA would operate as an intermediary to facilitate the relationship between PCA and Kudelski while providing outreach, awareness, and the selection process. Kudelski Human Resource (HR) team members provided administrative support, including offer letters and onboarding paperwork, managing changes to wage schedules, and providing non-technical supervision.

Program Outline

Outreach, awareness sessions, and open houses were conducted by Kudelski and CFA during the spring semester of PCA students' sophomore year for students, caregivers, and teachers. Interested students are required to apply and participate in interviews to further explore their interest in technology, cybersecurity, and to discuss students' technology-related school or personal experience or projects. Differences between internships and apprenticeships and the four-year commitment are also explicitly discussed. Team exercises are used to make final selections.

Students take courses in software development (game design, application development, and web development) in additional to traditional courses in English, Math, Science, and Spanish. During students' junior and senior years courses in networking and cybersecurity are taken alongside traditional courses of English, Math, Science, and History. Table 1 outlines the coding academy course sequence. Additionally, Kudelski Security provides related OJT covering topics outlined in Table 2.

Coding Academy Course Sequence – 2023-2024		
Graduation Requirements	**Frosh 1**	**Frosh 2**
4.0 Electives	Software Development 1	Software Development 2
	Exploring Computer Science 1-2	
4.0 Math	Integrated Math 1-2	
4.0 English	Eng 1	Eng 2
3.0 Science		
3.0 Social Studies		
3.0 World Language	Spanish 1	Spanish 2
1.0 Fine Art	Art 1	Art 2
.5 Health (PXU)		
Graduation Requirements	**Soph 1**	**Soph 2**
4.0 Electives	Software Development 3	Software Development 4
4.0 Math	Integrated Math 3-4	
4.0 English	Eng 3	Eng 4
3.0 Science	Bio1/Chem1	Bio2/Chem2
3.0 Social Studies	World History 1-2	
3.0 World Language	Spanish 1	Spanish 2
1.0 Fine Art	Art 1	Art 2
.5 Health (PXU)		

Graduation Requirements	Junior 1	Junior 2
4.0 Electives	*Networking and Cybersecurity 1	*Networking and Cybersecurity 2
4.0 Math	Integrated Math 5-6	
4.0 English	Eng 5	Eng 6
3.0 Science	Environmental Science	
3.0 Social Studies	World History 1-2	
3.0 World Language	Spanish 3	Spanish 4
1.0 Fine Art		
.5 Health (PXU)		
Graduation Requirements	**Senior 1**	**Senior 2**
4.0 Electives	*Networking and Cybersecurity 3	*Networking and Cybersecurity 4
	Gifted Seminar (open to all students)	
4.0 Math	*College Algebra	
4.0 English	Eng 7	Eng 8
3.0 Science	*Physics 1-2 (optional)	
3.0 Social Studies	Govt/Econ	
3.0 World Language		
1.0 Fine Art	Art 3	Art 4
.5 Health (PXU)	Health	
* Dual Enrollment with Phoenix College		

Table 1 – Phoenix Coding Academy Course Sequence (PCA Course Sequence, 2024)

Kudelski OJT Outline	
Year 1	Systems, Networking, Firewall Management, Active Directory Infrastructure, IT Support
Year 2	Phishing Campaigns, Security Risk Management, Cloud Computing, Threat Intelligence
Year 3	Client Engagement, Vulnerability Management, Burp Suite, Penetration Testing
Year 4	Vendor Support, Security Frameworks, Information Security Tools, Security Analysis
Continuous	Business Writing, Communication Across Generations, Culture Competency, Embracing Change, Emotional Intelligence, Establishing Goals, Excel, Project Management, Professionalism in the Workplace

Table 2 – Kudelski Security OJT Outline

Apprentices are provided the opportunity to study and test for industry-recognized certifications. These include several CompTIA certifications (IT Fundamentals+, Network+, Security+), Juniper, F5, Security Journey, Amazon Web Services (AWS), Proof Point, and Open Source Intelligence (OSINT).

Program Costs

The primary cost of the program is the hourly rate paid to apprentices which is subject to increases based on participation in the company's formal annualized performance and salary review process. Apprentices are eligible for education and training-related funding consistent with the Kudelski's U.S. tuition assistance program. Additionally, apprentices are eligible for pro-rated benefits depending on the average number of hours worked. Other major costs include the portion of time technical leads allocate to apprentices away from their primary job role, and the cost of time provided by Kudelski HR personnel supporting the apprenticeship program. Additional costs include laptops provided to students for post-secondary courses, external training, equipment and/or materials for training and education, and certification associated costs deemed appropriate for the apprentices.

4. OUTCOMES AND LESSONS LEARNED

Outcomes

The Kudelski-PCA Youth Apprenticeship program launched in September 2019 with two apprentices. As of spring 2024, the two apprentices from Cohort 1 and one apprentice from Cohort 2, completed their fourth and final year of the apprenticeship and all were offered and accepted roles as Tier 1 Cybersecurity Analysts, demonstrating that apprentices became valuable members of the team during their apprenticeship and were positively perceived by colleagues. Additionally, there are currently four apprentices in each of the four years of the

apprenticeship program, and all apprentices are continuing from one year to the next. The apprenticeship program has demonstrated that individuals can develop the KSAs needed for a Cyber Security Analyst role without a four-year degree, although all three apprenticeship completers, and all of the high school graduates, are pursuing post-secondary education in Arizona, demonstrating apprenticeship as a model for college and career. Additionally, of the 16 current apprentices and three apprenticeship completers, eight are female, eleven are male, and 61% identify as Hispanic, demonstrating the ability to attract and retain diverse talent for cybersecurity apprenticeships.

Several other high level outcomes were identified:

- Kudelski increased program participants from two per year to accepting between four and five apprentices, indicating program success, organizational support, and improved and streamlined processes supporting the apprentices.
- The apprenticeship program continues to attract more students and applicants each year indicating positive perception of the program and status of the opportunity.

Challenges

As with all new programs, several challenges were identified. The first was scheduling. While Kudelski's Cyber Fusion Center operates 24/7, non-security operations center employees on the Kudelski team predominately work Monday through Friday, primarily from 8 am to 5 pm. This limited the days and hours students could complete their OJT hours, requiring students to be released from school during normal classroom time. Fortunately, PCA's principal and lead educator supported this based on the unique opportunity to provide directly related hands-on experience complementing or replacing missed classroom time during students' junior and senior years. Also, this provided a unique experience to learn extremely important professional skills in addition to the technical skills. Further, it was occasionally necessary for students to take online classes to balance their academic and apprenticeship schedules. Fortunately, due to COVID, PCA and students became adept at working with online courses.

The COVID pandemic was the second challenge which began during the first year of the apprenticeship program. COVID-related school and business restrictions required moving apprentices to a remote and virtual experience for the first two cohorts. Students were allowed to return to the workplace when PCA returned to in-person classes in March 2021. PCA, CFA, and Kudelski maintained frequent remote meetings to ensure sustained communication and progress in the apprenticeship and student success.

Transportation represented another challenge. Most students do not drive or have reliable transportation. A bus-line was located approximately 15 minutes from PCA and was one source of transportation to Kudelski, but alternative forms of transportation were required placing an additional burden on caregivers or others, especially for students to return home. Kudelski's sustained commitment to the apprenticeship program and increased volume in students provided the ability for PCA to secure a bus to assist with transportation, beginning in 2022. Third and fourth-year apprentices continue to rely on caregivers and public transportation as their primary source of transportation.

Finally, it became clear early in the apprenticeship program, that attention was needed to address the challenge of student apprentices who were required to transition from being teenage friends and classmates in the morning to peers and work professionals at Kudelski Security in the afternoon. This required time and adjustment for the apprentices as this was their first job experience. Additional HR-related training was developed to help apprentices better understand appropriate and inappropriate behavior in the workplace. Support was provided to help Kudelski staff mentor and guide young adults.

Lessons Learned

The success of the apprenticeship program to develop qualified talent for the security operations team was due first and foremost to the commitment of the Kudelski CEO and his executive team and the understanding across Kudelski Security of the importance of this initiative. The second core element was the opportunity for the apprentices to have on-going exposure to and use of state-of-the-art, high-tech tools, and work with and learn from experienced technical leads in a live environment. Additionally, apprentices observed and participated in meetings with customers which provided critical experience and context.

Kudelski's HR support, which coordinated work experiences, was a critical component of the apprenticeship program especially as the program reached maximum size across the four years. Exercising schedule flexibility for exams and projects, family priorities, and occasionally

allowing a student time to return to a solid level of academic performance, was often the purview of the HR team to manage internally. Additionally, HR team roles changed throughout the program. They facilitated updates to content and delivery models as the program grew and technical leads changed due to differing work assignments. They handled HR-related questions and issues with apprentices and caregivers. This work and flexibility was critical to the success of the program.

CFA provided the intermediary role. Facilitating the partnership and relationships between Kudelski and PCA and ensuring understanding of the business and education environment was a critical component to program sustainability. Kudelski's HR and technical leads changed during the third year of the apprenticeship. The consistent and ongoing engagement of both intermediary CFA and school partner PCA, along with the unwavering commitment of Kudelski CEO and his team ensured a successful transition.

Caregiver support cannot be overestimated. The 4-year commitment to the apprenticeship, support for missing class time in years one and two, and providing transportation are critical elements that make the apprentices and the program successful, as both caregivers and students navigate a new experience. Related, is the importance of organization, prioritization, and time management developed by apprentices and supported by caregivers.

Apprentices were required to share and report on research and projects they accomplished, resulting in the development of strong presentation, verbal and written communication skills. Additionally overlapping projects across apprenticeship years provide opportunities for more senior apprentices to lead assignments or projects with supervision from technical leads to develop leadership skills which proved to be a good model for apprentices' growth.

5. FUTURE WORK

The apprenticeship program will continue with the sixth cohort of four juniors in the fall 2024-2025 school year. Year six will focus on enhancing opportunities for the apprentices to explore additional career choices beyond direct security operations roles. Additionally, planning for the potential that upon completion of the apprenticeship some apprentices may not meet the needs of Kudelski or may want to pursue options outside of Kudelski, will also be part of future considerations.

Having successfully completed two full four-year cycles provides the opportunity for reflection and analysis. Documenting the OJT curriculum for use internally and externally, and presenting at technical and workforce conferences, as well as meeting with interested companies and school districts, will be pursued. Documentation of high school partner and intermediary roles will be evaluated and completed as part of process refinement. Successfully managing the apprenticeship program during COVID also provides the opportunity to consider alternative or virtual apprenticeship models. Identifying forms of financial support to offset program costs or replicate the program with other companies and school districts will also be explored.

6. CONCLUSIONS

The cybersecurity youth apprenticeship program described in this paper demonstrated a viable solution in addressing the cybersecurity workforce shortage by providing hands-on training and work experience to students. The program's longevity and growth can be attributed to the unwavering commitment of the administrators and teachers at Phoenix Coding Academy, Kudelski Security's executive and technical teams, and the caregivers and students involved in the program. The apprenticeship's focus on developing technical skills, professional attributes, and leadership abilities resulted in a pipeline of qualified talent for the security operations team. The program's adaptability to the challenges posed by COVID-19 demonstrates an ability to pivot and maintain momentum despite unforeseen circumstances. The importance of HR support, caregiver involvement, and organizational commitment ensured the success of this initiative.

This apprenticeship model offers valuable insights for organizations seeking to develop their own talent pipelines or address similar workforce shortages. Specifically, the program's emphasis on experiential learning, mentorship, and leadership development highlights the importance of investing in the next generation of cybersecurity professionals.

Future work is essential to refining the model for continuous improvement and expansion to other organizations or states. Additionally, exploring alternative or virtual apprenticeship options and identifying forms of financial support to offset costs or replicate the program with other companies and school districts is needed. The Kudelski Security Apprenticeship Program serves as a model for innovative workforce development

initiatives, demonstrating that by investing in the next generation, organizations can build a more skilled and diverse workforce and drive business success.

7. REFERENCES

Ainsworth, H. and Eaton, S. (2010, July 31). Formal, non-formal and informal learning in the sciences. Onate Press. https://files.eric.ed.gov/fulltext/ED511414.pdf.

CareerWise (2024). Making Youth Apprenticeship a Reality. https://www.careerwiseusa.org/our-story/.

"Cyberseek Supply and Demand Heat Map," (2024), Cyberseek.org, https://www.cyberseek.org/heatmap.html.

"How the Economy, Skills Gap, and Artificial Intelligence are Challenging the Global Cybersecurity Workforce," (2023), International Information System Security Certification Consortium (ISC2), https://media.isc2.org/-/media/Project/ISC2/Main/Media/documents/research/ISC2_Cybersecurity_Workforce_Study_2023.pdf?rev=28b46de71ce24e6ab7705f6e3da8637e.

Kudelski Security (2024). About Us. https://kudelskisecurity.com/.

Lerman, R., Loprest, P., & Kuehn, D. (2020, October), "Training for Jobs of the Future: Improving Access, Certifying Skills, and Expanding Apprenticeship," IZA Policy Paper, No. 166, Institute of Labor Economics (IZA), Bonn, http://hdl.handle.net/10419/243452.

NCEE (2024). Global Perspectives: Expanding Youth Apprenticeships: Taking a Page from Switzerland. National Center on Education and the Economy (NCEE). https://ncee.org/quick-read/expanding-youth-apprenticeships-taking-a-page-from-switzerland/#:~:text=Swiss%20employers%20see%20it%20as,companies%20regularly%20hire%20student%20apprentices.

NCES (2023). Phoenix Coding Academy School Directory Information. National Center for Education Statistics (NCES). https://nces.ed.gov/ccd/schoolsearch/school_detail.asp?Search=1&DistrictID=0406330&ID=040633003509.

"NICE Apprenticeship Program Finder", (2024), National Institute of Science and Technology National Initative for Cybersecurity Education, https://www.nist.gov/nice/apprenticeship-finder.

NIST NICE (2022, January 10). NICE Cybersecurity Apprenticeship Program Finder. National Institute of Science and Technology (NIST). https://www.nist.gov/itl/applied-cybersecurity/nice/resources/apprenticeship-finder.

Page, L., Narel, R., & Beligio, E. (2020), "Skills Gap Challenge: How Apprenticeship Programs Address Skill Building and Educational Advancement," Journal of Organizational Psychology, Vol 20(6), https://articlearchives.co/index.php/JOP/article/view/4668/4630.

PCA Course Sequence (2024). Coding Academy program of study for 2023-2024 school year. https://www.pxu.org/domain/5481.

PCA (2024). Phoenix Coding Academy Welcome. https://www.pxu.org/coding.

"Protecting Digital Infrastructure: Securing Talent in Cybersecurity," (2024), Cybersecurity Youth Apprenticeship Initiative (CYAI), https://www.apprenticeship.gov/sites/default/files/CYAI_cybersecurity-skills-in-demand.pdf.

PXU (2024). Phoenix Unified School District (PXU). https://www.pxu.org/info.

Ross, W. and Duke, E. (2018). "Supporting the Growth and Sustainment of the Nation's Cybersecurity Workforce: Building the Foundation for a More Security Amerian Future," Secretary of Commerce and Secretary of Homeland Security, https://www.nist.gov/itl/applied-cybersecurity/nice/resources/executive-order-13800/supporting-growth-and-sustainment.

"State of Cybersecurity 2023: Global Update on Workforce Efforts, Resources, and Cyberoperations," ISACA, https://www.isaca.org/state-of-cybersecurity-2023?utm_source=other&utm_medium=other&utm_campaign=pr_both_content_survey-report_state-of-cybersecurity-survey-2023_quarter-3-2023_state-of-cybersecurity-2023-press-release&utm_content=state-of-cybersecurity-survey-2023_state-of-cybersecurity-2023-press-release&cid=pr_3000043&Appeal=pr

Stoker, G., Clark, U., Vanajakumari, M., and Wetherill, W. (2021, April). Building a Cybersecurity Apprenticeship Program: Early-Stage Success and Some Lessons Learned. Information Systems Education Journal (ISEDJ). https://files.eric.ed.gov/fulltext/EJ1297604.pdf.

Wagner, P. (2023, May 19). "CyberEducation-by-Design: Developing a Framework for Cybersecurity Education at Secondary Education Institutions in Arizona," https://scholar.dsu.edu/theses/430/.

White, A. and Bunce, J. (2023). Generative AI and cybersecurity: Bright future or business battleground? Sapio Research. https://info.deepinstinct.com/voice-of-secops-v4-2023?_ga=2.86841240.1038042311.1705606129-1595372854.1705443616.

White House (2022, November 15). FACT SHEET: Biden-Harris Administration Accomplishes Cybersecurity Apprenticeship Sprint. The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2022/11/15/fact-sheet-biden-%E2%81%A0harris-administration-accomplishes-cybersecurity-apprenticeship-sprint/