

Digital Badges and E-Portfolios in Cybersecurity Education

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Abstract

This paper reports on an effort to develop a digital badging and e-portfolio environment that will illuminate and assess curricular, co-curricular, and extracurricular learning in cybersecurity. This effort includes Cal Poly Pomona and Coastline College, which are both designated as Centers of Academic Excellence in Cyber Defense (CAE/CD) along with a collection of academic and industry partners in creating learning pathways that move interested beginners all the way through an exciting career in the field of cybersecurity. The pathways are designed to incorporate curricular, co-curricular, and extracurricular learning in a student-managed process in which students consume the learning modules they desire/need and which move them toward the learning goals they have chosen. Students will be able to see how formal curricular programs align with their learning journey and plan curricular, co-curricular, and extracurricular learning tasks that fit their plan and allow them to achieve their academic and career goals.

Keywords: Digital badge, e-portfolio, assessment, cybersecurity, education

1. INTRODUCTION

Malcolm Gladwell's prescription of 10,000 hours of practice being required to attain proficiency is an appropriate benchmark for cybersecurity (Manson & Pike, 2014). Reviews of skills required

by employers for cybersecurity positions support the notion of students needing extensive training to secure meaningful employment in the field. The mismatch between the skills cybersecurity students can reasonably attain within the classroom and those required by employers

demonstrates a need for students to become independent learners and add to their own skills. Furthermore, Generation Z students are argued to have learning needs and interests that are not, and cannot be, met within current college campuses (Seemiller & Grace, 2017). Generation Z students are also argued to be skeptical of the cost of higher education but are entrepreneurial, innovative and independent learners (Seemiller & Grace, 2016). The need for extensive skills training and the current inclination of the newest generation of students to be self-directed and entrepreneurial in their learning creates an ideal environment for digital badges and e-portfolios.

Cal Poly Pomona

Cal Poly Pomona prides itself on a "learn by doing" philosophy that extends well beyond students completing "hands-on" exercises in classrooms. A recently retired professor in Computer Information Systems (CIS) promoted a 50/50 equation meaning that students should ensure that at least 50% of their learning occurs outside of their degree requirements. The CIS program at Cal Poly Pomona promotes competitions, research, internships, and student club activities as venues for the "other" 50%. This "other" 50% focuses on competency-based education with students designing, planning and operating the programs and activities that comprise the learning with support from faculty and university resources.

In the past four years, the university has developed the Mitchell C. Hill Student Data Center (SDC) that operates as a hybrid-cloud facility along with a Security Operations Center (SOC) that students operate to monitor the SDC along with studying and researching in the area of cybersecurity operations (Hwang, Pike, & Manson, 2016). There is a companion Malware Analysis Lab (MAL) operated by computer science students that focuses research and learning in the area of computer malware. These facilities are brought together with others under the Cyber Security Instructional Research Project (CSIRP) at Cal Poly Pomona as an extension to the academic programs on campus. The SDC provides compute capabilities for learning modules in courses, competitions, research projects, and more. The SDC also provides cybersecurity learning environments for middle and high school students.

Initially, students worked as many as 10 hours per week and would invest several hundred hours of work in the Student Data Center (SDC) or Security Operations Center (SOC) during their time in the program. However, as the program

grows, some students are working as many as 20 hours per week and starting in their 2nd year in the program thereby amassing thousands of hours of work in the SDC and/or SOC during their time in the program. All of this time devoted to the operations of the SDC and SOC are filled with meaningful learning experiences yet few, if any, are captured in a student's transcript.

During the four years the SDC and SOC have been operating, the technical skills required of students within the SDC have continued to rise. After just the first year of the program, students who wanted to start in the SDC or SOC were unable to engage in either of the facilities as they lacked the needed skills. The SWIFT (Students With an Interest in the Future of Technology) student club jumped in and hosted workshops on topics from Linux, to computer networking, and more in an effort to prepare students for participation in the SDC and SOC. SWIFT developed an organizational unit called SWIFT Academy that focuses on such training.

Student staff from the Student Data Center (SDC) and Security Operations Center (SOC) then teach additional higher-level workshops that build upon the earlier workshops taught by students from SWIFT or other campus clubs. An ecosystem has emerged in which students are teaching workshops that have learning objectives, syllabi, and pedagogies that are subject to an approval process. Students are also running a production hybrid-cloud data center and security operations center. There is a defined set of prerequisites between the workshop courses and workshop completion requirements for Cal Poly Pomona students to start working in the SDC or SOC.

Student-led workshops have already begun to spill into course curriculum and vice versa. In some cases, faculty will recommend students in their class attend a particular workshop and even offer course credit or extra credit for participation. In other cases, faculty will adopt the content from a workshop and insert it into his or her course as a project or curriculum module. Likewise, student clubs will sometimes take popular technical modules from courses or even incorporate training (with permission) and create workshops from them for students that will not be taking the particular course, or students who need to learn the technical skill before they take the course that contains the content.

The process of teaching workshops along with operating competitions and participating in research projects along with the SDC and SOC engages more than 100 students. Many of these

students dedicate hundreds or thousands of hours of time learning and practicing the skills required, which in nearly all cases, are not reflected in transcripts. More than 1,000 students attended these workshops and programs during the 2018-2019 academic year. Digital badges were determined to be perhaps the only tool capable of creating a companion instrument to a student's transcript displaying students' skills and activities demonstrated within the curricular, co-curricular, and extracurricular programs at Cal Poly Pomona. E-Portfolios were determined to be the appropriate instrument to display pathways created through badges leading students to their desired learning goals as well as being the tool that will allow students to represent their learning journey along with the evidence to demonstrate their skills.

Coastline College

As a 2-year degree awarding institution, Coastline College (Coastline) recognizes the value of developing pathways for students coming in from the high school and those planning to go on to the 4-year schools after completing a 2-year degree at Coastline. To draw in students from the local middle schools and high schools, Coastline has developed pathways to engage these students with events and activities that include Cybersecurity Pathway Days, CyberTech Girls events, GenCyber summer camps, and cyber defense competitions such as CyberPatriot and Capture-the-Flag. These events are held at Coastline's Garden Grove campus to build the relationship between the students and the college faculty. The activities include training and hands-on workshops that raise awareness about Coastline's cybersecurity program and help students develop their skills and interest in cybersecurity professions.

Hosting these types of events, allows Coastline to go beyond the traditional type of outreach held at the middle school and high school campuses in which students talk to faculty at a table without much time for hands-on activities. By hosting the cybersecurity activities at the college campus, Coastline College showcases the classroom equipment and helps students from the 8th-12th grades to become familiar with the college setting.

Additionally, Coastline College offers dual and concurrent enrollment courses at the high school campuses in the Orange County, CA area. The concurrent enrollment courses offered at Santa Ana Unified School District (SAUSD) are taught by Coastline College faculty and the high school students from SAUSD are bussed to one high

school campus for class meetings. This allows the high school students to earn college credit while in high school and begin their cybersecurity skills development in preparation for cybersecurity roles or for their extracurricular activities at Coastline College or Cal Poly Pomona's SDC and/or SOC.

Coastline College's dual enrollment with La Quinta High School (LQHS) in Garden Grove includes college-credit courses taught during the regular high school day, by a LQHS teacher. The courses at La Quinta High School include Network+, Security+, and Ethical Hacking which will provide LQHS students with cybersecurity skills that they can continue to develop at the community college or university level, if they choose to continue on with their education.

Coastline College has established agreements with 4-year institutions through the Learning 1st Program, allowing Coastline students to enroll in both the 2-year degree courses and 4-year degree courses at Coastline and a University concurrently. This is sometimes referred to as a 2+2 program in which students receive full transfer credit from the 2-year school to the 4-year school's bachelor's degree program. The student completes 2+2 program to earn both the associate and bachelor's degree by taking classes at both schools in a major with pre-determined courses.

2. LITERATURE REVIEW

There is a growing body of literature around digital badges revealing optimism regarding their potential impact. Terms including digital badges, micro-credentials, or even credentials denote web-enabled depictions of an individual's accomplishments or skills (Gibson, Ostashewski, Flintoff, Grant, & Knight, 2015). A first key area of common ground within the literature focuses on the ability of digital badges to reveal learning pathways, making these pathways transparent to learners (Pitt, Bell, Strickman, & Davis, 2019)(Davis & Singh, 2015; Gibson et al., 2015; Pitt et al., 2019). These learning pathways can be a mix of formal curriculum in an academic program along with co-curricular or extracurricular learning activities.

Conversely, the pathways can be completely comprised of extracurricular activities including industry-based learning and badging/certification options. A second key area of common ground within the literature focuses on the ability of digital badges to validate possession of a key skill (Gibson et al., 2015; May, 2016). Examples of

skills validation for employees is evident in the literature and trade outlets from industries spanning human resources to AV installation, and education to construction (Berry, Airhart, & Byrd, 2016; "First micro-credential A big step forward for construction," 2018, "Introducing microcredentials for AV installation," 2017, "NPA introduces parking safety certificate program: Micro-credential program provides parking facility safety and risk reduction tools," 2016; Goerner, 2016; Gorlin, 2018).

Literature varies on the appropriate scope of a digital badge. There is strong support in the literature for a badge reflecting an individual skill or accomplishment (Goerner, 2016; May, 2016). Others; however, add to this by comparing badges today to e-commerce in the latter 1990s with the notion that education providers who ignore badges could begin a steady decline (Hickey, 2017).

E-portfolios have an immense literature base that reflects many uses for this technology. E-portfolios are used in classrooms as a way to assess student learning and in program-level assessment (Wang & Jeffrey, 2017). E-portfolios are also used as digital resumes for students to display evidence of learning to potential employers or higher-level education admissions, or to demonstrate professional development in an individual's workplace.

The review of literature focused on education, nursing and law. Education was a point of focus as we are deploying e-portfolios in an education setting. Medicine and law were reviewed as they are professional disciplines and have been argued to be appropriate reference disciplines for information systems (Davenport & Markus, 1999). Within medicine, we focused on nursing literature as it has a strong applied focus that matches well with cybersecurity.

The first major benefit found for e-portfolios centers around learners' self-reflection and self-regulated learning (Carl & Strydom, 2017; Chin-Yuan Lai & Cheng-Chih Wu, 2016; Rafeldt et al., 2014). A second major benefit of e-portfolios was found in helping learners to tell a media-rich story related to their learning journey (Haverkamp & Vogt, 2015). Yet another benefit of e-portfolios found in literature is the ability to link theory to practice (Chittum, 2018; Cunningham, Bartesaghi, Bowman, & Bender, 2017). There are many more benefits of e-portfolios that cannot be fit into this paper, we have simply reported on the dominant benefits we found pertaining to the goal of this paper. Also, there is a large literature base supporting the three

benefits of e-portfolios we are presenting which have been limited to just the few that best supports the purpose of this paper.

3. DIGITAL BADGES & E-PORTFOLIOS

We examined digital badges and e-portfolios to enhance and assess co-curricular and extracurricular student activities that support the information systems program at Cal Poly Pomona. The ability to accurately assess co-curricular and extracurricular work is especially important in a polytechnic setting as we focus significant resources and importance on these activities. We sought to determine the efficacy of these technologies with respect to serving as a tool to report student-learning outcomes in activities that span formal curriculum as well as co-curricular and extracurricular activities. Digital badges are increasingly important as they are a specific measure of skills achievement that tie to workplace demands.

Digital badges can also provide skills achievement in co-curricular and extra-curricular programs between schools. For instance, a student may earn badges in high school that allow them to start in more advanced opportunities at the community college. Badges from high school and community college may allow students to start work right away in the Student Data Center (SDC) or Security Operations Center (SOC) at Cal Poly Pomona without spending the year that is typically required to gain the skills to start in these facilities. This is especially important for transfer students to ensure they get started immediately in these facilities as they only have two years to complete their degrees.

Digital Badges

A digital badge is a shareable credential providing evidence of a learning achievement. Digital badges fall into two categories which are competency and participation badges. A competency badge requires an assessment of skills and measures of achievement. The badge includes the items that were assessed and the performance outcome that was required to earn the badge. Participation badges indicate a person participated in an event such as attending a workshop or lecture. The badges are sometimes offered in tandem where an individual attends a workshop and then has an opportunity to take a skills test at the end.

We found support in the literature for three distinct drivers supporting the use of digital badges. The first is the potential motivation for students in earning a badge as an extrinsic

reward for excellence or even drive engagement by linking students' achievements within a leaderboard and creating a competitive element to learning (Denny, 2013; Gibson et al., 2015). Second is the potential for a digital badging system to help students envision integrated curricular, co-curricular and extracurricular learning paths that prepare them to enter careers (Pitt et al., 2019). Third is the potential for digital certifications to help students market themselves to potential employers. We found support for the notion that companies are seeking ways to gain additional insight into the skills and abilities of applicants and digital badges are a potential solution (Raish & Rimland, 2016). We also found evidence that CIOs are seeking to gain insight into the skills of current employees meaning that digital badges may already be a valued asset in IT organizations before a student applies (May, 2016).

More than a dozen employers of cybersecurity students from Cal Poly Pomona have asked for the implementation of badging systems. Employers such as IBM and AWS have entered into a joint badging process in which students earn some badges from Cal Poly Pomona and some from these companies while they are in school. Cisco has recently announced a scaling back of their certifications programs and the implementation of digital badging. This process of digital badging appears to be growing and we believe it will become pervasive over time.

Figure 1 shows a brief example of a learning pathway which is overly simplified for demonstration. In this case, a student took an AP Python course in high school, a networks course from a community college and a Linux course from Lynda.com. This group of badges/certifications allowed the student to qualify for the SOC Associate badge at Cal Poly Pomona which is a collection of sub-badges. The student then is able to jump right into the SOC Associate role in the SOC at Cal Poly Pomona (CPP) and begin working on the Splunk certification, which is earned directly from Splunk, and the SOC Operations badge which comes from completing 100 hours of work as an analyst in the SOC and successfully completing a battery of tasks. A student can progress through this process without any formal articulation agreements as the SOC (along with the SDC) are extracurricular environments. Of course, proper planning should ensure that the AP Python class taken in high school and the Networks class from the community college each articulated to appropriate courses in the CPP curriculum. The student will likely not receive academic credit for

either the Linux course or Splunk certification but she or he would have known this in advance and been able to plan accordingly.

E-Portfolios

As noted in the literature review, we found three distinct drivers for the use of e-portfolios which were learner self-reflection, learner storytelling and linking theory to practice (Carl & Strydom, 2017; Chin-Yuan Lai & Cheng-Chih Wu, 2016; Chittum, 2018; Cunningham et al., 2017; Haverkamp & Vogt, 2015; Rafeldt et al., 2014). Portfolium has been selected and procured for use in our e-portfolio and digital badging venture.

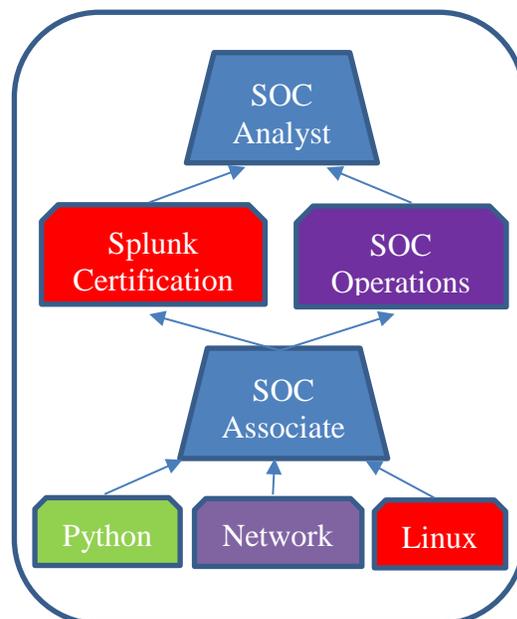


Figure 1 SOC Learning Pathway

E-Portfolios and Digital Badging

At Cal Poly Pomona digital badging and e-portfolios are implemented in Portfolium, a commercial product. Portfolium is a complete solution so that badging and e-portfolios are completely integrated. Badges can also be output into LinkedIn and other platforms from Portfolium. The benefits derived from e-portfolios and digital badging for our program are shown in Table 1. The integration of e-portfolios and digital badging, and then the subsequent integration of these two technologies to our existing systems such as our LMS (Learning Management System) have been reviewed; however, are expected to create a challenge throughout our e-portfolio/badging implementation process.

Benefits of E-Portfolio and Digital Badging	
E-Portfolio	Digital Badge
Self-reflection	Extrinsic motivation
Storytelling	Illuminate learning pathways
Linking theory to practice	Market to employers or higher-level education

Table 1 E-Portfolio and Digital Badging Benefits

A number of literature sources speak to e-portfolios supporting learning and evidence of achievement (Trevitt, Macduff, & Steed, 2014). However, in our environment we view digital badging as being the tool that offers evidence of achievement and the e-portfolio supporting learning. Likewise, we are planning to use e-portfolios to support learning in a mixed environment of curricular, co-curricular, and extracurricular work but this will overlap to at least some extent with the function of our LMS. The process of determining which information is maintained, managed and assessed in which systems will certainly create lively debate among stakeholders on campus.

4. OPPORTUNITIES FOR FUTURE RESEARCH

While previous research and the findings of the study provide a promising framework for pathways with supplemental credentialing through digital badging and micro-certificates housed in an e-portfolio repository, there are areas that need additional attention and research to move the framework forward. There is a need to understand the process for establishing, articulating, and updating industry and higher education standards for badging and e-portfolios. Following this idea, is a need to measure the rate or speed of digital badging and e-portfolio adoption by industry and higher education. Finally, once badging and e-portfolio standards are established and fully implemented there needs to measure the impact of digital badging and e-portfolios on rates of graduation, transfer, job attainment, job promotion, and employee retention.

5. CONCLUSION

E-portfolios and digital badging are an exciting option to extend cybersecurity learning and provide/illuminate pathways for learners. Cal Poly Pomona and Coastline College are both designated as Centers of Academic Excellence in Cyber Defense (CAE/CD) and are working with academic and industry partners to make technical skills pathways transparent to learners from middle school all the way into professional careers. This project focuses on empowering learners to understand the challenges and opportunities ahead of them and crafting/refining a learning journey that includes a broad array of content and potential patterns to consume the content. We envision learners ultimately assembling an academic transcript and a e-portfolio with digital badges that summarize the learner's preparation for a career. This learning journey then continues as the learners manages career advancement and market shifts in the workplace.

6. REFERENCES

- Berry, B., Airhart, K. M., & Byrd, P. A. (2016). Microcredentials. *Phi Delta Kappan*, 98(3), 34-40.
- Carl, A., & Strydom, S. (2017). e-Portfolio as Reflection Tool during Teaching Practice: The Interplay between Contextual and Dispositional Variables. *South African Journal of Education*, 37(1).
- Chin-Yuan Lai, & Cheng-Chih Wu. (2016). Promoting Nursing Students' Clinical Learning Through a Mobile e-Portfolio. *CIN: Computers, Informatics, Nursing*, 34(11), 535-543.
- Chittum, J. R. (2018). The Theory-to-Practice ePortfolio: An Assignment to Facilitate Motivation and Higher Order Thinking. *International Journal of ePortfolio*, 8(1), 27-42.
- Cunningham, S., Bartesaghi, M., Bowman, J., & Bender, J. (2017). Re-Writing Interpersonal Communication: A Portfolio-Based Curriculum for Process Pedagogy and Moving Theory into Practice. *International Journal of Teaching and Learning in Higher Education*, 29(2), 381-388.
- Davenport, T. H., & Markus, M. L. (1999). Rigor vs. Relevance Revisited: Response to

- Benbasat and Zmud. *MIS Quarterly*, 23(1), 19–23.
- Davis, K., & Singh, S. (2015). Digital badges in afterschool learning: Documenting the perspectives and experiences of students and educators. *Computers & Education*, 88, 72–83.
- Denny, P. (2013). The effect of virtual achievements on student engagement. *SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*, 763–772. New York, NY, USA: ACM.
- First micro-credential A big step forward for construction. (2018). *Real Estate Monitor Worldwide; Amman*.
- Gibson, D., Ostashevski, N., Flintoff, K., Grant, S., & Knight, E. (2015). Digital badges in education. *Education and Information Technologies*, 20(2), 403–410.
- Goerner, P. (2016). Give That Expert a Badge. *School Library Journal*, 62(12), 20–21.
- Gorlin, R. (2018). Early impressions of SHRM's new california micro-credential. *HRNews*.
- Haverkamp, J. J., & Vogt, M. (2015). Beyond academic evidence: Innovative uses of technology within e-Portfolios in a doctor of nursing practice program. *Journal of Professional Nursing*, 31(4), 284–289. <https://doi.org/10.1016/j.profnurs.2015.03.007>
- Hickey, D. T. (2017). How Open E-Credentials Will Transform Higher Education. *Chronicle of Higher Education*, 63(32), 13–13.
- Hwang, D., Pike, R., & Manson, D. (2016). The Development of an Educational Cloud for IS Curriculum through a Student-Run Data Center. *Information Systems Education Journal*, 14(1), 62–70.
- Introducing microcredentials for AV installation. (2017). *Systems Contractor News*, 24(20).
- Manson, D., & Pike, R. (2014). The case for depth in cybersecurity education. *ACM Inroads*, 5(1), 47–52.
- May, T. (2016). Evolution of the CIO: The real story. *Computerworld Digital Magazine*, 2(7), 36–37.
- NPA introduces parking safety certificate program: Micro-credential program provides parking facility safety and risk reduction tools. (2016). *PR Newswire*.
- Pitt, C. R., Bell, A., Strickman, R., & Davis, K. (2019). Supporting learners' STEM-oriented career pathways with digital badges. *Information and Learning Science*, 120(1), 87–107.
- Rafeldt, i L. A., Bader, H. J., Lesnick Czarzasty, N., Freeman, E., Ouellet, E., & Snayd, J. M. (2014). Reflection Builds Twenty-First-Century Professionals. *Peer Review*, 16(1), 1–7.
- Raish, V., & Rimland, E. (2016). Employer Perceptions of Critical Information Literacy Skills and Digital Badges. *College & Research Libraries*, 77(1), 87–113.
- Seemiller, C., & Grace, M. (2016). *Generation Z Goes to College*. San Francisco, CA USA: Jossy-Bass.
- Seemiller, C., & Grace, M. (2017). Generation Z: Educating and Engaging the Next Generation of Students. *About Campus*, 22(3), 21–26.
- Trevitt, C., Macduff, A., & Steed, A. (2014). [E]portfolios for learning and as evidence of achievement: Scoping the academic practice development agenda ahead. *The Internet and Higher Education*, 20, 69–78.
- Wang, P., & Jeffrey, R. (2017). Listening to learners: An investigation into college students' attitudes towards the adoption of e-portfolios in English assessment and learning. *British Journal of Educational Technology*, 48(6), 1451–146.

