Motivating STEM+C Learning with Social Impact of Cybersecurity and Digital Forensics

Eoghan Casey
Cyber Sleuth Science Lab
Baltimore, US
ORCID: 0000-0001-7219-317X

Karen Peterson
National Girls Collaborative Project
Seattle, US
kpeterson@ngcproject.org

Daryl Pfeif
Cyber Sleuth Science Lab
New Orleans, US
daryl@cybersleuthlab.org

Cassy Soden
Cyber Sleuth Science Lab
New Orleans, US
cassy@cybersleuthlab.org

Abstract—This work describes the design, development, implementation and research of the Cyber Sleuth Science Lab (CSSL), an innovative educational program and supporting virtual learning environment created to provide young women and men from traditionally underserved populations (grades 9-12) with digital forensic knowledge, skills and career pathways. CSSL combines online and in-person classroom elements that challenge students to become cyber sleuths learning to use real-world digital forensic methods and tools to solve goal-based investigative scenarios, and to explore complex social issues related to technology. Classroom activities provide additional support and role model engagement to encourage youth to consider STEM+C related careers while improving their cyber street smarts. This research uses a quasi-experimental, comparison group design combining qualitative and quantitative methods.

Keywords—Equity, problem-based learning, career pathways, cybersecurity, digital forensics

I. Introduction

Cybersecurity and cybercrime are growing rapidly and present real-world challenges related to technology. In addition, there is a major shortage of qualified candidates in Cybersecurity and Digital Forensics. Notably, relatively few women enter this dynamic workforce sector, which is in stark contrast to other forensic science disciplines which attract many more women than men. The primary research questions in this work relate to effectiveness of instructional methods and career pathway pursuit. Specifically, we are studying the effectiveness of the CSSL for teaching digital forensic proficiency that is directly applicable in the workplace, and for inspiring young women and other underrepresented youth to pursue STEM+C related careers. An overarching question in this work is whether young women show interest in digital forensics and cybersecurity in specific, and computer science education in general, and related technical skill development when it is situated within a learning environment that explores the complex issues associated with cybercrime, such as criminal justice, legal considerations, and information privacy.

II. Scientific-inquiry-based Pedagogical Framework

The Cyber Sleuth Science Lab (CSSL) combines a sophisticated virtual learning environment hosted in the cloud with rich goal-based scenarios and supporting educational resources to fuel in-classroom instructional activities and career pathway exploration. Investigative scenarios in the CSSL are constructed with input from youth dealing with issues that are directly relevant to their lives, including cyberbullying, privacy, account hijacking, identity theft, anonymous harassment, unauthorized sharing of personal photographs. Computational thinking is codified with the CSSL interface and instructional activities. For students, learning support resources are embedded with the CSSL platform. Educators and students are supported by facilitators who circulate in classrooms to address technical issues and student questions. A Teacher Dashboard allows educators to track student progress. Each student is also able to view personal progress completing activities through their individual Dashboard.

III. Program Development

The CSSL program has a flexible modular design that is adaptable to different contexts in school and out of school. Development started in 2017 and pilots were run in Baltimore, New Orleans and Washington State, summarized in "Table I". Embedded assessments, in-person surveys, and automated data gathering are combined to gain insights into experiences and outcomes for students and educators and facilitators.

TABLE I: PILOT OVERVIEW

Venue	Details			
	Students	*Duration*	*Hrs/day*	*Total hrs (est.)*
Baltimore 2017	12	1 day	6	6
NOLA 2017	30 (4+26)	1-2 days	6	6
Baltimore 2018	79	4 days	6	24
NOLA 2019	17	1 week	6	30
Everett 2019	12	3 weeks	6	78
Baltimore 2019	32	5 weeks	1	24

Initial focus groups and pilots of the CSSL helped determine the needs of youth and educators in the target environments. The initial pilots were structured as a focus group of 12 young women in Baltimore City schools, and two groups of female students in New Orleans (4 for 1 day, 26 for 2days), all

grades 8-12 (most with prior computing education). A pilot in 2018 was conducted simultaneously in four classrooms, as part of a larger summer program supporting Baltimore City Schools. The 79 students (40% female, 58% male from traditionally underserved populations) ranged from grades 9 through post-graduation with the majority in grades 10-12. These students completed two investigative missions over three days, answered formative and summative questions, wrote final reports, some of which were presented in front of the class orally. An extra Industry Day brought students from all four classrooms together with expert practitioners who discussed their career pathways and then divided into smaller groups for questions and answers. A final convention of all students was held to wrap-up the program, announce achievement awards, and encourage continued pursuit of STEM+C.

In 2019 multiple pilots were held in Baltimore, New Orleans (71% female, 29% male) and the Everett (50% female, 50% male), supported by Washington Network for Innovative Careers (WANIC). The Everett pilot was the most extensive, requiring the educator and CSSL team to work closely together to create a complete program for 78 total hours. Students were able to complete all investigative scenarios, present their work in class, have structured reflection sessions, and interactions with multiple guest speakers (practitioner role models). In addition, a mock trial was held between the second and third investigative missions, dividing the class into three teams (prosecution, defense, forensic expert witnesses) to present evidence-based arguments, with communication focusing on forensic findings rather than theories of guilt/innocence. The facilitator was from a local community college enrolled in a cybersecurity and digital forensics program, and she had opportunities to present new topics to the students and work with them on content related matters.

IV. Outcomes and Lessons Learned

Across all pilots, the young women and men who participated in the CSSL program were inspired and engaged by their experiences, and developed an increased knowledge and interest in Digital Forensics and Cybersecurity. Students particularly benefited from playing the role of investigators and getting hands-on experience with real-world digital forensic tools to help someone recover deleted data or deal with cyberbullying. The majority of students indicated that the program provided them with enough educational supports, and that they learned skills that are useful for a career, and expressed increased interest in and knowledge of digital forensics and cybersecurity.

After the CSSL program, students expressed surprise about how easy it is to access and recover information from digital technology, and had a heightened awareness of risks associated with technology use. In addition, many students had a broader view of careers related to cybersecurity and digital forensics and the experiences of professionals in these career, and wanted to learn more about pathways into these careers. Overall, across both 2018 and 2019 pilots, young women developed a slightly higher interest in Digital Forensics and Cybersecurity than young men. Interestingly, during the 2019 pilots, young women expressed a significantly larger change in appreciation and interest than young men.

A summary of primary lessons learned through implementation of the CSSL:

- *In-classroom Activities*: students benefit from in-classroom activities, not just online instructional activities.
- *Supporting Girls*: girls benefit from special support in co-ed learning environments.
- *Career Quest*: youth benefit from a structured approach to exploring career pathways.
- *Super Cyber Sleuths*: some students complete investigative missions more quickly and need additional learning activities.
- *Classroom Management*: teachers benefit from an enhanced Teacher Dashboard to help them manage classroom activities, track student progress and performance more flexibly and effectively. An added benefit of this tracking mechanism is that educators had students view their own individual progress and see what they still needed to complete.
- *More Time*: exploration takes time, and cannot always occur within an hour of classroom time.
- *Professional Development*: educators benefit from more supports, guidance and time to become familiar with the CSSL before bringing it into the classroom.

V. Conclusions

The CSSL program provides a rich multidisciplinary learning experience, combining STEM+C with social issues. Young women and young men are motivated to learn more about cybersecurity and digital forensics, but perhaps with a different focus. Young women appear to be more motivated by social issues such as safety and privacy, whereas young men seem to be more motivated by career choices. Although students enjoy learning in the digital platform through investigative missions, they benefit from "outside of the computer" activities such as structured in-classroom discussions, mock trials, and in-person interactions with practitioner role models. Young women favor such in-classroom activities relative to young men who tend to prefer seeking supports in the digital platform.