CyberSecurity and Technology: How Do They Fit into a Science Classroom?

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This study bridges discipline silos between science courses and computer science by indicating how they fit into and complement each other. A study of eight K12 teachers and 26 K12 secondary students participated in a GenCyber (cybersecurity) camp for a week during July 2018. External evaluations of the camp show its success and how cybersecurity fits into science and mathematics classrooms. This GenCyber camp was a five-day introductory camp for middle school and high school teachers and students. The GenCyber camp offered morning modules of CORE instruction, or cyber-oriented reinforced education, with the afternoon focused on differentiated learning adventures for teachers and students in specialized subject options engaging in hands-on labs. Most instruction utilized Micro:bit technology. Teachers and students made explicit connections to chemistry (battery function chemistry, sensors), physics (frequency, particle vs. wave, movement, acceleration, photon detection, magnetic fields), biology (simulating biological behavior, synchronizing, pattern detection) and mathematics (matrix, functions, modeling, unit conversion).

1. Introduction and Challenge in science education:

As there is currently a push for computer science and computational thinking in K-12 US schools (Google, 2016), the authors’ of this study questioned how K-12 teachers could connect science (as well as mathematics, technology, and engineering) content within a GenCyber camp curriculum. GenCyber is sponsored by the National Security Agency and the National Science Foundation to expose and reinforce cybersecurity education. The GenCyber camp at the University of Wyoming was called COWPOKES-CS which stands for CyberCamp of Wyoming: Providing Opportunities, Knowledge, Experiences, and Security through Computer Science.

Although as an educational community we realize that “computer science is becoming ever increasingly important to our society. Computer science content has, however, not traditionally been considered a natural part of curricula for primary and secondary education” (Heintz, Mannila, & Fanqvist, 2016, p 1). Since computer science has traditionally been a “university level discipline with no widely accepted general standards for what computer science at K-12 level entails” (Heintz, Mannila, & Fanqvist, 2016, p 1), science and mathematics teachers often do not see a connection with their disciplines and computer science. The idea of teaching computer science in a science or mathematics class often seems foreign to K-12 US teachers. Additionally, even though computer science is considered a pure subject with its own disciplinary structure and hierarchy, (like traditional biology, chemistry and physics) a linear “programming-first” approach is used most often when teaching students computer science across North America (Cooper, Dann, & Pausch, 2003). There is debate to this programming
first approach, as to whether it works well (Burrows, Borowczak, Slater, & Haynes, 2012; Connolly, Murphy, & Moore, 2009). However, as an educational community we do know that real-world applications of computer science are not common in K-12 school settings (Barr & Stephenson, 2011), although this approach is accepted as best practice in STEM disciplinary content (Burrows, Breiner, Keiner, & Behm, 2014; Jimoyiannis, 2010). If computer science is not seen in K-12 schools, cybersecurity which has a high principle overlap with computer science, is also not present. Yet, importantly, Grover & Pea (2013) point to “computing as a medium for teaching other subjects” (p. 42), or integration, as needing further exploration.

This GenCyber camp’s purpose (and the place where the study was conducted) was to use an active inquiry model to teach middle school and high school students and teachers about cybersecurity first principles, ethics, foundations of computer science (through Block and Python programming of Micro:bits) and introduce concepts of computational thinking for implementation into STEM coursework. Micro:bits were chosen because they have high functionality, low cost (~$15), and provide an ease of integration into any IT setting. Thus, any K-12 school can afford and use them. In the morning session both teachers and students worked together, and the focus was on three core areas: foundations of computer science, computational thinking, and cybersecurity first principles. In the afternoon sessions, teachers and students were split into separate groups as they worked through a variety of lab sessions reinforcing concepts presented earlier in the day.

The labs utilized included: physical security, password cracking, forensics, hardware hacks, AI/Robotics, and the future of cybersecurity. Hardware hacks and password cracking were required for all participants, but the other labs were optional, allowing participants to experience all labs sessions or to focus on one or two and explore them in-depth. All of the created labs, which speak directly to new innovative technology use, can be found at this link: https://uwcedar.io/community/cowpokes/wikis/home.

The following four figures, created using the NGSS Pathfinder (https://concord.org/ngss/), show the connections between the created labs and the Next Generation Science Standards including the disciplinary core ideas, crosscutting concepts, and science and engineering practices (NGSS Lead States, 2013).
Figure 1: NGSS DCI, CCC, and SEP for the Microbit:Fitness:Tracker Activity.

Figure 2: NGSS DCI, CCC, and SEP for the Microbit:LockPick Activity.
Figure 3: NGSS DCI, CCC, and SEP for the Microbit:Bot Wars Activity.

Figure 4: NGSS DCI, CCC, and SEP for the Microbit:Beacon Activity.
For reflection, the teachers were scheduled to have two sessions to discuss and develop lesson plans with the educational leader each day. Questions about in-classroom technology use (e.g., Micro:bits) and integration into STEM disciplines were common. For one of the sessions, teachers remained for an hour longer working and reflecting on lesson plan development. As proposed, teachers led these sessions and used their experiences to develop lesson plans tailored to their teaching assignments and aligned to the state’s curriculum. The camp’s objectives included:
1. Helping K12 students and teachers understand correct and safe on-line behavior
2. Increasing participants’ interest in cybersecurity
3. Improving teaching methods for delivering cybersecurity content in K12 CS curricula – especially science and mathematics

Specially, the research questions included:

- Was the GenCyber camp considered beneficial to teachers and students?
- How did the teachers and students connect science (and mathematics) content to the cybersecurity camp?

An external evaluator examined interview and survey data of the camp and it is summarized here as evidence of the camp’s success at integration of cybersecurity into the camp and K-12 classrooms. Additionally, the camp leaders utilized developed lesson plans and discussion to tease out teacher and student science (and mathematics) content connections.

2. The Study’s Research Results

Overall, the GenCyber camp was considered beneficial to both the K-12 teachers (n=10) and secondary students (n=60). The camp’s teachers and students found and highlighted ways to connect cybersecurity to science and mathematics content.

Quantitative Findings
Teachers and students engaged in the camp and found meaningful STEM connections.

The external evaluator noted that student participant engagement during whole group instruction with participants authentically on task at 75%, student participants passively engaged at 25%, and student participants disengaged/disruptive at 0%. Student participant engagement during activities with participants authentically on task at 85%, student participants passively engaged at 10%, and student participants disengaged/disruptive at 5%. For learning activities completed individually, 100% of students were reported authentically on task.

Similarly, the teacher participant engagement during whole group instruction with participants authentically on task at 85%, teacher participants passively engaged at 15%, and teacher participants disengaged/disruptive at 0%. Teacher participant engagement during activities with participants authentically on task at 80%, teacher participants passively engaged at 20%, and teacher participants disengaged/disruptive at 0%. For learning activities completed individually, 100% of teachers were reported authentically on task. Significantly, 87% of the middle and high school teachers reported that they were already formulating plans for taking concrete actions to integrate cybersecurity into their classes.
Teachers showcased the integration of the technology use (e.g., Micro:bit) by including it in lessons directly from NGSS - DCI, CCC, and SEP including: 1) DNA (HS-LS1-1; HS-LS1-6; HS-LS3-1; HS-LS3-2; HS-LS4-1); 2) Structure and Function; 3) Earth’s Systems (MS-ESS2-6); 4) Weather and Climate; 5) Waves and their Applications in Technologies for Information Transfer (MS-PS4-1; HS-PS4-2); and 6) Waves and Electromagnetic Radiation.

**Qualitative Findings**

Positive comments from teachers and students revolved around the micro:bits, computer part understanding, password security, and activities/labs. Teachers and students made explicit connections to chemistry (battery function chemistry, sensors), physics (frequency, particle vs. wave, movement, acceleration, photon detection, magnetic fields), biology (simulating biological behavior, synchronizing, pattern detection) and mathematics (matrix, functions, modeling, unit conversion).

During the camp, teacher and student participants particularly enjoyed learning about security, coding, the interactive projects, and the Micro:bit challenges. The STEM teachers reported that they would be able to use the Micro:bits in their classrooms for math and science classes. All eight teachers felt they could incorporate lessons on safe on-line behavior and digital footprints in their classes. All eight teachers felt confident that they could create a quality STEM lesson plan incorporating cybersecurity. (Note: The created lesson plans will be shared during the ASTE session and available online in the public domain.)

The external evaluator noted that the Micro:bit badge and activities were exceptional. The badge served as each participant’s nametag, a portable power source for other activities, an informal assessment tool, an interactive extension activity, and with a different Micro:bit attached, it was used for the Beacon scavenger hunt. Each participant kept their badge, and all 34 participants were excited about how they could use the Micro:bit for other activities at home and at school. (Note: The Micro:bit Beacon scavenger hunt activity - as well as the Micro:bit itself will be shared during the ASTE session.)

Additionally, the external evaluator reported that “the unplugged (no computer necessary) activities were exceptional. These activities could be used in any classroom setting, but also could be used to scaffold lessons that then led to using technology. Many of the activities were also very challenging and required participants to think through the lesson that was presented and apply the concepts to their personal lives.” (Note: Several of the unplugged activities are showcased shared during the ASTE session as well.)

3. Items presented for those in attendance to learn in addition to the study details include:

Researchers already know that computational thinking and computer science are important skills. However, what is not known is if a one-week cybersecurity experience can allow teachers and students to make connections to STEM subjects. The GenCyber camp shows that computer science and cybersecurity fit into science and other STEM disciplines. In addition to the quantitative and qualitative results presented here, materials for use with K-12 students and pre-service or in-service teachers are shared. During the ASTE session the Micro:bit itself, activities
with it, lesson plans, and unplugged activities are shared with the audience. The authors of this paper argue that a cybersecurity focus can enhance STEM learning in K-12 classrooms.

4. Justification for inclusion in science teacher education:

A major component of the cybersecurity camp was the development of skills within the science/math and cybersecurity context. The STEM teachers and students learned how to use cybersecurity concepts and make connections to STEM content, while engaging in Micro:bit activities. Furthermore, the cybersecurity camp aligns with standards (e.g., NGSS) that current science (and math) teachers are required to consider as they create lessons. If the computer science discipline is included in the advancement of the STEM mission, then the teachers of all disciplines – who also shape all careers – could be empowered to highlight these cybersecurity STEM aspects in schools.

Limitations: This camp covered a small portion of time (two weeks). By collecting data in other camps, a more detailed picture of the science (and mathematics) connections could emerge. Some of the data was collected and analyzed by an external evaluator and some by the camp leaders, and thus the process to reach a conclusion was surely different and no inter-rater reliability was conducted.

5. ASTE interested members:

Methods instructors, educational researchers, teachers, curriculum developers, and those interested in STEM integration, computer science, and cybersecurity would be interested in this study.

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References


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