Cultivating Elementary Students' Interest in Cryptography and Cybersecurity

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Background

- Shortage of cybersecurity professionals (NAS, 2018).
- Universities and community colleges are starting to address the issue. However, cryptography and cybersecurity are barely taught in k-12 classrooms.
- K-12 grades, especially elementary level, is when disciplinary dispositions and career aspiration begin to form (Tran, 2018).
- In 2013, women made up 11 percent of the global cybersecurity workforce (Frost & Sullivan, 2013). By the end of 2019, the number is predicted to increase to 20 percent (Cybersecurity Ventures, 2019).
- Cryptography is the foundation of cybersecurity (Paar & Penzl, 2010).
- Skills underlying the basic encrypting and decrypting practices in classic cryptography requires a fundamental understanding, awareness, and sensitivity in making sense of language, while more recently, mathematical algorithms (Swenson, 2008).
- Encrypting and decrypting practices in classic cryptography parallel the skills children must develop to gain morphological awareness and become successful readers, writers, and symbolic analysts (Reich, 1992).

Aim of this project

- Design and develop a technology-enhanced curriculum and education model for afterschool learning context;
- Engage elementary school students in making and breaking codes;
- Develop morphological and symbolic systems awareness and analytic skills;
- Develop interest and understanding of cryptography and cybersecurity;
- Develop appreciation of cryptography and cybersecurity education pathways and careers;
- Develop STEM identity for students, especially girls and minority students.

Curriculum design

Learners
- Upper elementary (3-5th grades)
- African American Females and others

Context
- Nonformal learning context: multiple afterschool programs
- 6 weeks, 3 hours per week

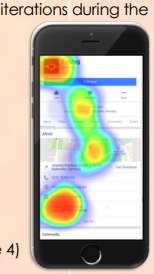
Curriculum
- *Storyline to guide the curriculum*
- *Game-based activities*
  - Imitate decryption concepts and process in a classroom activity Make paper cup and string phones to introduce telegram
  - Anagrams, word puzzles, Bingo, Jigsaw, etc.
  - Embodiment: use gestures to represent cryptology concepts
- *Integrating codebreaking with arts using hands-on art activities:*
  - Cipher wheels (figure 1)
  - Navajo rugs and Adinkra stamps to practice encoding and decoding symbolic codes
  - Using Egyptian hieroglyphics to create student names
- *Developing role models in cryptology to build career path*
- *Creating cultural relevant learning context*
- *Integrating math, science, and computer science*
  - Neutralization of acids and basics: creating invisible ink;
  - Using number codes to learn operations and functions;
  - From Morse code to Binary
- *Integration language arts and history*
  - Using short reading materials and videos to introduce historical events
- Field trip to Florida Institute for Cybersecurity
  - Cybersecurity awareness

Touch-based application
- Encoding and decoding (figure 2)
- Gestures

Formative evaluation from practitioners
- Afterschool teachers provide ideas, feedbacks and suggestions during curriculum design and development stage

Research

- **Feasibility of the curriculum**
  - Formative evaluation during year 1 in multiple iterations during the design and development process.
  - Summative evaluation during year 2
  - Measures
    - Student and teacher Interview
    - Classroom observation
    - Teacher journal
    - Survey for students and teacher
- **Usability of the application**
  - Screen recording
  - Classroom recording
  - Interview
  - System Usability Scale
  - Eyetracking to measure visual attention (figure 4)
- **Learning outcomes**
  - Morphological awareness: Affix Identification task (Ebbers, 2004)
  - Visuospatial ability
    - Mental folding test for children (Harris, Hirsh-Pasek, & Newcombe, 2013).
    - Mental Rotation Task for Children (Wiedenbauer et al., 2008)
  - Cybersecurity awareness test (project develop)



Collaboration

- Kids Count
- Girls Place
- Caring and Sharing
- Blue Wave
- Florida Institute for Cybersecurity

Figure 1. Cypher wheel

Figure 2. A screenshot of the touch-based mobile app

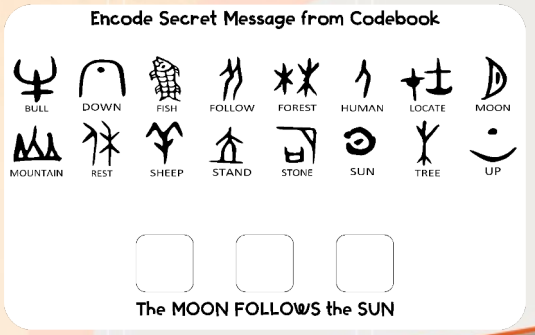


Figure 3. Book Cipher