STRATEGIES: Codebreakers: Cultivating Elementary Students' Interest in Cryptography and Cybersecurity Education and Careers

This ITEST Strategies project introduces a new technology-enhanced STEM education model for engaging upper elementary students in cybersecurity and morphological awareness experiences, and STEM identity development in the new and exciting context of making and breaking secret codes. It is informed by the following NSF ITEST question:

- What culturally-responsive instructional and curricular practices and models enhance student understanding of and interest in STEM occupations, and what factors influence the outcomes of the practices and models?

Our project is based on a simple but previously unexplored and potentially transformative idea. Cryptography is the backbone of cybersecurity, and the skills underlying the 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. The mystery of the subject, its relevance in today's society, and interactive, gamified learning experiences will engage the children, and the afterschool environment will provide a safe space for them to learn at their own pace, improving development of students' STEM identity, self-efficacy, computational thinking, literacy, and interest in cybersecurity. The immediate focus of our design-based research program is to conduct a systematic investigation of the effective conditions for designing and implementing touch-screen enhanced visuospatial learning curricula that foster STEM interest and career awareness using the unique context of cryptography.

Intellectual Merit

Strategic integration of cryptography, cybersecurity, and morphological awareness to engage upper elementary students in integrated STEM learning, as well as our research on the role of touch-screen technology on girls' and boys' visuospatial cognition will advance the science of STEM learning in several societally important ways:

- We are proposing a unique approach to expand our conceptions of STEM education by introducing a novel technology-enhanced model that fuses cybersecurity, cryptography, and morphological skill development.
- We may be the first research and development team to explore the feasibility of engaging elementary students in cybersecurity education and career explorations using the rich and interdisciplinary context of cryptography.
- We explore the effects of Human Technology Frontier-enabled touch-screen technology on the visuospatial cognition of young learners, specifically girls, potentially enhancing their learning and self-efficacy in STEM.
- We contribute fundamental knowledge regarding elementary students' STEM identity development as a result of engaging in a technology-enhanced cryptography curriculum featuring industry role models and mentors.
- We generate important empirical data on elementary students' existing (mis)conceptions and evolving understandings of cybersecurity, cryptography, and the associated education and career pathways.
- We investigate the uses and effects of our model nationally, in a more diverse but less studied context of elementary afterschool education, focusing our efforts on enhancing the experiences of girls and African American students, and addressing federal calls for more R&D on broadening participation in STEM.

Broader Impacts

Cybersecurity is a major challenge in the flat, global society of the 21st century and so it is troubling that the US is experiencing an extreme shortage of cybersecurity professionals. Our focus on cryptography has important implications for developing problem solvers and data scientists prepared to tackle the cybersecurity challenges of the 21st century. The Codebreakers project will impact at least 28 afterschool educators and 550 upper elementary students, most from underrepresented populations. We have strategically partnered with afterschool programs that serve large proportions of girls and African American children to engage them in the new and exciting STEM context—the making and breaking of secret codes. We will develop elementary-level cybersecurity education resources that currently do not exist and make them widely accessible to K-12 formal and informal educators, parents, and the public. Our research on the role of touch-screen technology relative to sex differences in visuospatial cognition may help level the playing field for girls and their visuospatial reasoning in STEM education. We will also support a number of female and African American graduate and undergraduate student mentors. A total of about 160 elementary preservice teachers will participate in curriculum implementation as a required field experience. We will disseminate the results of Codebreakers via CryptoClubs, a national network of programs and our partner. The infrastructure for research and education will be enhanced by strategically leveraging existing partnerships (e.g., CryptoClub, Florida Institute for Cybersecurity Research) and creating new partnerships with Raytheon (a global cybersecurity company), cybersecurity educators special interest groups, and community stakeholders. The resultant network will create new opportunities for the promotion of K-12 cybersecurity education, which is an important but challenging goal.