Assisting K-12 Teachers to Make the Connection between Computational Thinking in Cybersecurity Unplugged Activities and Mathematical Mindset through A Cybersecurity Micro-credential

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This poster focuses on K-12 STEM teachers' computational thinking while using unplugged cybersecurity activities and exploring cybersecurity applications within self-paced micro-credentials. As a result, they share the most successful and challenging unplugged cybersecurity activities. The pilot micro-credentials were created to assess their effectiveness at enabling K-12 teachers to meaningfully their own materials to develop students' STEM readiness and increase their engagement with cybersecurity, while enabling unplugged activities to transfer to a more mathematical mindset. The two pilot studies, focusing on K-12 teacher participants, included an initial micro-credential in the 2020 summer (n=5) which informed and enhanced a second micro-credential module sequence in the fall 2020 semester (n=16). Pilot 2 consisted of a total of five modules after refining it from feedback from pilot 1, which had only 2 modules. Researchers performed a mixed-methods study, which included qualitative data collected through interviews and focus groups. Additionally, content knowledge questions and attitude surveys were also used to collect both qualitative and quantitative data. Results indicate that the majority of K-12 teachers who participated in the micro-credential pilots were able to make connections between unplugged activities and a mathematical mindset. The poster presents these findings and also includes additional resources for further exploration and inspiration.

Keywords: Micro-credential, Cybersecurity, Mathematical Mindset, Computational Thinking, Unplugged Activities

1. Introduction

Currently, there are not enough qualified teachers (e.g., computer science teachers, STEM teachers) to fill the needs in computer science education, in particular, cybersecurity education (Gal-Ezer & Stephenson, 2009; Lye & Koh, 2014). To fill this gap, educational systems can offer more opportunities for professional development virtually and through micro-credentials (Borowczak, Mugayitoglu, Burrows, Kennedy, Carson, & Person, 2020; Dede, Eisenkraft, Frumin, & Hartley, 2016). For this reason, the authors have developed a user-friendly, high-quality, and content-rich micro-credential opportunity for professional development. The micro-credential consists of interdisciplinary (e.g., STEM) resources and research. The micro-credential

has 5 modules: (0) introduction to cybersecurity; (1) the CIA triad (confidentiality, integrity, and availability); (2) abstraction; (3) modularity; (4) least privilege. Each module consists of research materials (e.g., journal articles, book chapters, conference papers) and other resources (videos, websites, sample lesson plans, and STEM-related e-cybersecurity cards) for computer science teachers and STEM teachers. Through these modules, the authors provided up-to-date, content-rich resources and research materials that K-12 teachers could grasp easily and that comprehensively cover computer science/cybersecurity concepts and pedagogy.

Unplugged activities and lesson plans also included opportunities for K-12 teachers to reinforce computational thinking related to STEM (Science, Technology, Engineering, and Math) while teachers are learning cybersecurity concepts and principles. Therefore, K-12 teachers can generalize from the cybersecurity micro-credential to other subject areas (e.g., math, chemistry, physics, and biology). E-cybercards were designed based on computational thinking steps to connect cybersecurity and science subject areas such as biology (Algorithm design for modularity), chemistry (Decomposition for abstraction), and physics (Pattern recognition for layering). Therefore, these e-cybercards can help K-12 science teachers as they prepare and support their students in shaping their views of science, technology, math, and cybersecurity combinations.

Research questions

1. What were the unplugged cybersecurity activities and lesson plans successes and challenges identified by the participants?

2. How did K-12 teachers make connections between unplugged cybersecurity activities and a mathematical mindset/mathematical education?

2. Methods, Analysis and Findings

In Pilot 1, K-12 teachers completed 2 modules: (0) introduction to cybersecurity; (1) the CIA triad. In Pilot 2, K-12 teachers completed 5 modules: (0) introduction to cybersecurity; (1) the CIA triad; (2) abstraction; (3) modularity; (4) least privilege. Introduction to Cybersecurity was mandatory and K-12 teachers chose 2 more modules to complete the course. Module 0 takes less time than other modules (Module 1, 2,3, and 4) since there were no assessment requirements.

The authors collected data quantitatively and qualitatively via four methods: 1) content knowledge questions (quantitative); 2) attitude survey (quantitative); 3) thirteen semi-structured interviews (qualitatively); 4) two focus groups (qualitatively).

One K-12 teacher comment stated, “I was really engaged with the videos so those were really interesting to watch...I could connect some of those things into what I'm doing already with teaching math and science and how I could incorporate those...” Another K-12 teacher commented, “I had never really thought about some of the ways to connect it into science and math and things like that. So I think that’s great”

It is important to know that teachers were unlikely to read journal articles, book chapters, and e-books, but they preferred to watch short size and informative videos. Therefore, videos would be beneficial for teachers to learn new content while connecting with their subject area (e.g. math, science).

Computational thinking and cybersecurity unplugged activities allowed math and science teachers to get some ideas and inspiration. Additionally, these resources were beneficial for math and science teachers and provides teachers with pedagogical ideas to support them throughout the learning process via teaching computational thinking steps (decomposition, abstraction, pattern recognition, algorithm design, evaluation, and logic). These activities were beneficial in that they provided definitions of computational thinking steps and helped facilitate math and science teachers knowledge in relation to the material.

As a challenge of the unplugged activities, one K-12 teacher commented, “My lesson plans were geared towards virtual, but I looked at yours, and the unplugged and stuff, and my first thought was, Oh this is really cool! How could I turn this into a virtual thing to use now with my kids?” Another K-12 teacher commented, “I did wonder about people who had minimal computer science background, how well they would be able to connect things to classroom practices.”

Some teachers experienced challenges that new teachers often face when trying to adopt cybersecurity principles in their classes. Unplugged activities made the connections for some teachers (e.g., computer science teachers) between computational thinking, a mathematical mindset, and cybersecurity within real-world scenarios. However, unplugged cybersecurity activities were difficult to apply within the classroom for some teachers (especially STEM teachers). Researchers consider developing more unplugged activities based on cybersecurity principles for promoting teachers to utilize with their students not even in face-to-face classroom teaching, but also virtual classroom teaching as well.

3. Limitations, Conclusions, and Implications

Resources and journal articles provided K-12 teachers with information about the principles of cybersecurity and the fundamentals of computational thinking. The teachers were given opportunities to practice designing cybersecurity-centered activities and lesson plans. Therefore, they could transfer their content and pedagogical knowledge in mathematical mindset/education including abstraction, problem solving, and decomposition. It was important that researchers prioritized unplugged activities of computational thinking because of concerns with equity and accessibility for all teachers. These activities provided teachers with free, easy-to-access practical resources and research. One of the main limitations of this study is the paucity of research on the connections between the mathematical mindset, computational thinking, and mathematical mindset. Therefore, more research is needed in this area.

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