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Peng Jiang
Old Dominion University

Xin Tian
Old Dominion University

Chunsheng Xin
Old Dominion University, cxin@odu.edu

Wu He
Old Dominion University, whe@odu.edu

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Teaching Hands-On Cyber Defense Labs to Middle School and High School Students: Our Experience from GenCyber Camps

Peng Jiang
Xin Tian
Chunsheng Xin
Wu He
Old Dominion University
United States
pjian001@odu.edu
xtian@odu.edu
cxin@odu.edu
whe@odu.edu

Abstract: With the high demand of the nation for next generation cybersecurity experts, it is important to design and provide hands-on labs for students at the K-12 level in order to increase their interest in cybersecurity and enhance their confidence in learning cybersecurity skills at the young age. This poster reports some preliminary analysis results from the 2016 GenCyber summer camp held at Old Dominion University (ODU), which is part of a nationwide grant program funded by the National Security Agency (NSA) and the National Science Foundation (NSF). This poster also demonstrates the design of three hands-on labs which have been devised to be age-appropriate for middle and high school students.

Keywords: cybersecurity, hands-on labs, k-12 students

Overview:

A wealth of hands-on labs for teaching computer security and information assurance (IA) have been developed for college students. With the high demand of the nation for next generation cybersecurity experts, it is important to design and provide hands-on labs for students at the K-12 level in order to increase their interest in cybersecurity and enhance their confidence in learning cybersecurity skills at the young age. In this poster, the authors report some preliminary analysis in the 2016 GenCyber summer camp held at Old Dominion University (ODU), which is part of a nationwide grant program funded by the National Security Agency (NSA) and the National Science Foundation (NSF). Our camps provide interactive, hands-on learning activities to educate students about cyber security as a Science, Technology, Engineering, and Mathematics (STEM) education and career pathway. The 2016 GenCyber summer camps at ODU provide a week-long training for the middle school and high school students in three aspects: cybersecurity tutorials, panels, invited talks, three hands-on labs, and two field trips to the Navy and interactions with Navy cybersecurity experts. This poster demonstrates the design of three hands-on labs which have been devised to be age-appropriate for middle and high school students. We devised these labs based on the input from four high school teachers as well as instructional faculty in college of education, and made improvements after we tested them with our camp students. In addition, we surveyed middle school and high school students immediately after they completed the labs during the camps in terms of their perceptions and learning experience with our hands-on labs. Since there are few studies related to the cybersecurity hands-on lab training for students at the K-12 level, the data analysis results and findings from the survey will be beneficial for improving K-12 cybersecurity educational curriculum and helping to develop better hands-on labs for K-12 students.

Significance and Relevance of the Topic:

Hands-on cybersecurity labs allow students to learn cybersecurity concepts and principles by exploring and applying conceptual knowledge to real-world situations. Typically learners are provided with worked-out step-by-step instructions to facilitate the study of cybersecurity concepts and techniques. Increased use of hands-on cybersecurity labs has the potential to improve student learning of cybersecurity techniques and principles. Currently, the majority of hands-on cybersecurity labs are designed for college students and beyond. There are limited numbers of hands-on cybersecurity labs that are age-appropriate for middle school and high school students. Simply using hands-on cybersecurity lab designed for college students to teach middle school and high school students is inappropriate and does not work well because middle school and high school students have much less computer experience than college students. It has been reported that some college students also have difficulty in completing the hands-on cybersecurity labs (Guo et al., 2013). Thus, it is important to design and provide age-appropriate hands-on cybersecurity labs for K-12 students at the K-12 level. Otherwise, they may lose interest, motivation and confidence in learning cybersecurity skills, which will be counterproductive to the nation's efforts in increasing number of future cybersecurity professionals.

Before our 2016 GenCyber summer camps, the authors collaborated with high school teachers and educational faculty to discuss and design hands-on labs materials specifically for middle and high school students. During the camps, the authors also worked hard to update the lab materials based on the students' feedback and adopted different instructional strategies while teaching the labs to them. After the camps, we made further improvements to our teaching materials. One of the major goals in the poster is to illustrate the improved hands-on labs materials for the middle and high school students and report our analysis of the survey data collected during our summer camps.

Content:

The poster will contain two parts. First, we will show our improved hands-on labs materials and hands-out designed for middle school and high school students. The first hands-on lab is network traffic tracking and analysis. Students in this lab learn the basic network structure and rules to regulate network characteristics such as cabling types, access method, data transfer speed, and physical topologies. Then they learn how to track the trace of the data packets that are transferred in the network to understand how to do cyber defense from the very beginning. The second lab focuses on how to setup a Linux based firewall (pfSense) to protect a private network based on the knowledge of network protocols from the first hands-on lab. The second lab is divided into two parts. The first part helps them to understand the vulnerabilities of existing network protocols and ports opened in each system; the second part illustrates what is firewall and how to configure firewall rules to block certain protocols or ports which are vulnerable to potential attacks. The third hands-on lab is Wi-Fi password cracking and information hiding. Students learn how to crack a Wired Equivalent Privacy (WEP) key, and a Wi-Fi Protected Access (WPA) passphrase using the aircrack-ng utility, which is a suite of tools for Wi-Fi network security. After cracking the WEP key and WPA passphrase, students then decrypt the network traffic using airdecap-ng, e.g., they can view the HTML content after decryption. Students who have successfully exploited the vulnerabilities of Wi-Fi network will have a better awareness of the need to use strong passwords to protect their WiFi networks.

We will show the quantitative and qualitative results from student surveys. The key findings are as follows.

- Overall, most students agreed that the hands-on labs were enjoyable, and expressed their interest in learning more concepts and doing more cybersecurity labs.
- Overall, there was not a significant difference between male and female middle and high school students in completing the hands-on labs without any help. But girls (Mean: 3.80, Std. Deviation:1.874) seemed less confident than boys (Mean: 4.61, Std. Deviation:2.097) in terms of completing the hands-on lab on their own without any help.

- We also summarized a list of issues and challenges students had when completing the hands-on labs.

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