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The Effectiveness of a Hybrid Cybersecurity Summer Camp for Teachers

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Abstract

Cybersecurity teacher education plays a vital role in narrowing the gap in the need for cybersecurity professionals in the workforce. In this paper, the authors examined the effectiveness of a hybrid cybersecurity summer camp for secondary education in-service teachers. The pre- and post-camp quizzes showed significant statistical difference, $t(17) = -8.42$, $p < .001$, with a large effect size of 2.24. Focus group interviews with the teacher participants further suggested that the hybrid modality is not only viable but also a preferred format welcomed by the teachers.

Keywords

Cybersecurity, teacher education, hybrid.

Introduction

According to a recent study on the global cybersecurity workforce published by (ISC)² (2021), the shortage of cybersecurity workforce in 2021 is about 2.7 million globally. Among them, the United States is in need of 377,000 cybersecurity professionals. Over the past decade, the United States has made a significant effort in narrowing the gap in the need for cybersecurity professionals in the workforce. Most notably, the Bush administration launched the Comprehensive National Cybersecurity Initiative in 2008, and among them, is an initiative to expand cyber education in a coherent effort and develop an effective pipeline of future cybersecurity professionals to meet the demands of the job market (The White House n.d.). As part of the effort, the National Security Agency and the National Science Foundation jointly sponsored the GenCyber program in 2014 intending to broaden cybersecurity education at the K-12 level to spark the interests of students in pursuing further education on cybersecurity and potentially choosing cybersecurity as a career choice (GenCyber n.d.).

In summer 2021, we conducted a hybrid GenCyber cybersecurity summer camp for secondary education in-service teachers. Twenty-two participants attended and completed all the required lessons and learning activities. The teacher participants developed an interest in cybersecurity, acquired cybersecurity knowledge and hands-on skills, and developed unit plans that integrate cybersecurity concepts with their respective teaching areas upon completing the teacher camp. The teacher participants came with a broad spectrum of prior knowledge and skills since the summer camp required no prior computer programming or cybersecurity knowledge and experience. Thus, the purpose of this study is to determine the effectiveness of the hybrid cybersecurity teacher camp, as well as to reveal any observed factors for success and areas for improvement. The research questions we seek to answer are:

- Is the hybrid cybersecurity summer camp effective in teaching cybersecurity concepts to teachers?
- What are the observed factors for the success of the camp?
- What are the areas for improvement?

Related Work

With the increasing demand for cybersecurity education at the K-12 level, teacher education on how to teach cybersecurity topics becomes essential. Researchers have noted that teachers are not provided with sufficient training for teaching cybersecurity topics to students in grades K-12. In another word, teachers are generally not equipped with the necessary knowledge in the subject matter to teach cybersecurity topics effectively to K-12 students (Javidi and Sheybani 2018). In addition to the content knowledge in cybersecurity, we also need to prepare teachers with research-informed instructional approaches for teaching cybersecurity subjects (Chen et al. 2021). To help remedy the bottleneck with cybersecurity teacher education, various efforts, and initiatives such as GenCyber, TeachCyber.org, and Cyber.org, have been devised. For instance, from 2015 to 2019, 3711 teachers participated in these programs (Dark et al. 2021).

One of the shortcomings of cybersecurity professional development for in-service teachers is the lack of long-term support and the limited reach due to seating capacity. In contrast, the training of pre-service teachers has a much broader reach. Researchers have long recognized the importance of teacher education programs to prepare pre-service teachers to teach cybersecurity topics and safe online behaviors to future generations, so that they know how to conduct safe and ethical online activities (Agamba 2010; Pusey and Sadera 2011; Rahman et al. 2020). One such effort is a special topics course offered to pre-service teachers on introduction to computer programming and cybersecurity principles by Mississippi State University (Ivy et al. 2019). The authors noted that "creating new courses to integrate into existing teacher education programs allows us to reach preservice teachers already in the teacher pipeline" (Ivy et al. 2019).

Methods

Research Context

In summer 2021, the authors implemented a GenCyber cybersecurity teacher camp for 24 secondary in-service teachers. The camp was developed and delivered by the research team in a hybrid modality with a combined total of 35 instructional hours. The online portion of the teacher camp was delivered asynchronously with a flexible schedule. The face-to-face portion provides an environment for collaborative and hands-on lab activities. It also allows the participants to receive immediate feedback from both the instructors and their peers.

The content area of the camp focused on the GenCyber cybersecurity concepts, which include defense in-depth, confidentiality, integrity, availability, thinking like an adversary, and keeping it simple. In addition, the teacher camp also covered relevant topics such as privacy, cyberbullying, and common tools and techniques for cybersecurity risk management. As part of the camp activity, teachers developed cybersecurity unit plans that they could bring back with them and integrate into their classrooms.

In this case study, we compared the teachers' performance in the pre- and post-camp quizzes regarding their content knowledge of cybersecurity concepts and principles. In addition, a semi-structured focus group interview was conducted upon the conclusion of the cybersecurity teacher camp to gather feedback on the effectiveness of the camp, factors that contributed to the success of the camp, as well as suggestions for improvements for future camps.

Participants

Convenient sampling was used in this study. The participants consisted of 24 secondary education in-service teachers who participated in the GenCyber cybersecurity teacher summer camp. The participants were recruited from local middle and high schools in the surrounding region. The teachers were given a pre-camp quiz prior to the beginning of the camp activities and then were given the post-camp quiz upon the camp conclusion. Participation in the pre- and post-camp quizzes, as well as the group interview, was voluntary, and the teachers could opt out of them at any stage. Table 1 illustrates the demographic information of the participants.

	Variables	**Frequency**	**Percent**

Gender	Female	20	83.3
	Male	4	16.7
Ethnicity	Asian	1	4.2
	Black/African American	11	45.8
	Prefer not to respond	1	4.2
	White/Caucasian	11	45.8
Grades	6-8	13	45.8
	9-12	11	54.2
Subject	Computer Science/Cybersecurity	9	37.5
	STEM	6	25
	Other	9	37.5

Table 1. Demographics of the Teachers

Instruments

For quantitative data, the instrument consists of a set of pre- and post-camp quizzes. Each quiz consists of 15 multiple choice questions covering cybersecurity concepts and principles, which include but are not limited to confidentiality, integrity, availability, defense in depth, cyber threats and vulnerabilities, ethics, and privacy. Overall, 24 teachers completed the pre-camp quiz, and only 20 teachers completed the post-camp quiz.

Compared to individual interviews, focus group interviews can take place in a more informal field setting with the purpose of stimulating group discussions. It can add valuable insight to the understanding and explanation of an event (Frey and Fontana 1991). In this project, the semi-structured focus group interviews were conducted in 2 groups of 10 participants split into two classrooms using the same set of questions. The questions used in the semi-structured interviews were:

- What are the most useful aspects of this camp?
- What are the observed strengths of this camp?
- What can we do better to help teachers prepare to teach cybersecurity? Any suggestions?
- How did you like the hybrid modality of the camp? Any suggestions?

Results

Data from both the pre- and post-camp quizzes along with the transcriptions of the interviews were analyzed post the camp. The following subsections present the results from both the statistical analysis of the pre- and post-camp quizzes as well as the qualitative analysis from the interviews.

Statistical Analysis

We compared the results of the pre- and post-camp quizzes on teachers' content knowledge in cybersecurity topics. A paired sample *t*-test was conducted to investigate whether there was a statistically significant difference in teachers' pre- and post-test scores on the content knowledge of cybersecurity topics. Results showed that there was a statistically significant increase, $t(17) = -8.42$, $p < .001$, from 8.91 ± 1.49 to 12.57 ± 1.76, an improvement of 3.66 ± 1.84. The results showed that participating teachers gained and learned cybersecurity knowledge after the camp with a large effect size of 2.24.

Qualitative Analysis

The focus group interviews both revealed the strength of the camp and offered several recommendations for future improvement.

Success Factors

Teacher participants reported that the most useful aspect of this camp was the resources provided in the camp, which helped them transfer what they had learned to their teaching practice. The camp also offered a great foundation in the content knowledge of cybersecurity. The hybrid modality was welcomed by the participants as it reduced the required days of traveling but still offered opportunities for in-person interactions both among the participants and with the camp instructors. Participants praised these in-person interactions, especially for the face-to-face camp activities and collaborative unit planning.

The following are a few chosen quotes from the participants regarding the highlights of their experience.

- *I have a good understanding of the major elements of the field, certainly enough to teach it to middle schoolers. We were introduced to very engaging case studies that will be excellent for getting students interested and contextualizing the content.*
- *The lesson planning units that we created and presented are excellent resources, and they are ready to use. Also, many of the concepts we discussed relate to our learning standards.*
- *The camp highlighted real-world problems that students can relate to and made a career in cybersecurity an option for them.*
- *This camp gave me exposure to all the fundamentals of cybersecurity and has allowed me to collaborate with others to start the motion on how to implement all the cybersecurity concepts from an early age.*
- *All the lesson plans I have co-created with my team and shared by other teams will leverage the starting point for me to be able to utilize all this information when I launch the school-wide digital citizenship curriculum in the upcoming school year.*

Recommendations for Improvements

In addition to the success factors that were pointed out by the teacher participants, they also shared their recommendations for potential improvement in future camps. The teachers expressed their interest in having more hands-on activities during the face-to-face section of the camp. Despite having commended the high quality of the asynchronous online learning materials, the teachers also preferred to have scheduled synchronous meetings or office hours to highlight and explain important concepts for better understanding. The following are a few chosen quotes of their suggestions.

- *I would like to have connections with companies that will partner with me so I can give my students opportunities to engage with people who are in this field.*
- *Possibly give more activities that we teachers could bring to our classrooms to effectively convey the information.*
- *I would love more hands-on learning opportunities in which we can do ethical hacking.*
- *I'm old-fashioned so I would have liked a digital handout/catalog for downloading with the videos and a glossary of key terms.*

Discussion

Overall, the teacher participants shared an enthusiastic and positive attitude towards their learning experience in the GenCyber cybersecurity teacher camp. The results from the analysis of the pre- and post-camp quizzes indicated that the teachers achieved the desired learning outcomes. Considering that only 37.5% of the participants teach computer science or cybersecurity-related subjects, this is a testament to the quality and effectiveness of the program. The qualitative analysis further solidified the notion of the positive experience and that the camp has made an impact by enabling the teachers with the necessary knowledge and resources to teach cybersecurity topics in their schools. As we can see from the quotations from the teachers, the unit plans that they developed during the camp are a valuable resource and enabler for teachers to take action and transfer the knowledge that they have learned to their students.

Conclusion

As discussed in the paper, the GenCyber cybersecurity teacher camp delivered its goal by providing teacher participants with a comprehensive learning experience that not only allowed them to learn cybersecurity

concepts but also equipped them with resources and lesson plans that they can take away and integrate into their classrooms. The hybrid modality was a welcome and viable solution for such a program. Particularly in the case of an introductory cybersecurity program, the hybrid modality combines the best of both worlds with the abstract concepts and topics being offered in an online learning environment, yet still provides participants with ample opportunities for in-person interactions and hands-on activities in a lab environment.

Limitation and Future Work

Due to the limitation of the seating capacity, the sample size in the *t*-test is limited. Also, this study only measured the effectiveness of the teachers' learning through the means of pre- and post-camp quizzes. A more rigorous evaluation method should be considered in future studies. Since the goal of the camp was to enable teachers to teach cybersecurity in their respective classrooms, further analysis of teachers' self-efficacy in teaching cybersecurity topics, as well as their technological knowledge, pedagogical knowledge, and content knowledge are needed.

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