



# Evaluating Cybersecurity Instructional Strategies for Students



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## Introduction

- The cybersecurity environment has evolved significantly in recent times, increasing the risk for threats and vulnerabilities among organizations and ordinary citizens. Thus, increasing the need for ensuring privacy and security in the cyberspace.
- According to the National Institute of Standards & Technology, by 2025, "lack of talent and human failure" will be responsible for over half of cybersecurity incidents" (NIST, 2023).
- The demand for cybersecurity professionals has skyrocketed. As of September 2024, in the United States alone, there were approximately 448,033 unfilled cybersecurity positions (Cyber Seek, 2024).
- Middle school is a critical stage as students begin to solidify their academic interests and identities (Wigfield & Eccles, 2002).
- "There is a shortage of knowledgeable and skilled cybersecurity teachers at the primary, secondary levels and college levels" (Ross & Duke, 2018)
- A recent national study demonstrated that only 45% of K-12 educators indicated that students are learning about cybersecurity. This may be further exacerbated in small or low-income school districts (Buchanan, et al., 2021).

## Purpose

- This literature review aims to explore and analyze the types of cybersecurity instructions available to students in various levels of academia
- Through a literature review, we hope to identify different instructional resources available to students considering the significant shortage in cybersecurity professionals.
- Thus, identifying this will allow us to gain an understanding of the available recourses for students to increase their interest in the field of cybersecurity.

## Methods

**Databases:** IEEE Xplore, Web of Science

**Key Words:** Cybersecurity education, cybersecurity education resources, Middle school, College Students

**Number of articles:** 5 were identified to focus on cybersecurity educational resources among middle school students, and 1 briefly touched on elementary school students, 8 were focused on High School and Higher Education.

**Analysis:** In analyzing these articles, only 5 identified potential cybersecurity educational resources in tools embedded in elementary and middle school curriculums 8 were focused on high school.

**Inclusion Criteria:** Articles had to emphasize on students in various levels of academia, in addition to an educational resources and or tools aiding in the learning of cybersecurity concepts and material overall.

## Results

### Instructional Strategy Among Middle School Students

- The instructional strategy among middle school students was Games ( $n= 5$ ).
- Games Identified: Hackathons, Cryptoscratch, NetDefense Game, Branching Comics
- Curriculum: Teachers proposed their own curriculum with the integration of branching comics in an effort to create an introductory course for middle school students.

**Subjects Learned:** Cryptography, authentication, web security, software vulnerability, access control, modeling, integrity protection, hashing of algorithms, malware, defenses, phishing, anonymity, secure password creation, states of data (in use, in transit, at rest), network protocols, web tracking, discrete data packets, good and back packets, firewall placement, and network log analysis, education, career paths, jobs.

### Outcomes

- Students demonstrated increased comfort with complex concepts, gained knowledge and understanding of cybersecurity concepts, perception in student motivation, team collaboration, participation and interest in the field.

### Interesting Findings:

A study implemented an extended CryptoScratch program that provided various cryptographic algorithms as visual blocks, eliminating the need for mathematical premises not feasible for K-12 students. Eight cryptographic learning challenges were imbedded into the program as task blocks where their solutions were analyzed for security problems, accuracy and encouraged students to implement more security throughout these challenges. The post-test survey results revealed that 60% of students demonstrated comfort in the implementation of complex cryptographic schemes, while approximately 90% of students felt comfortable with cryptographic concepts overall (Percival, 2022).

#### Pre-Survey Results

Scratch Usage	N	%
Never	6	37.50
A little	5	31.25
Some	4	25.00
A lot	1	6.25

#### Post Survey Results

Student Response	Q1	Q2	Q3
Completely disagree	0	0	0
Somewhat disagree	2	1	0
Neutral	5	2	2
Somewhat agree	4	7	7
Completely agree	5	6	7

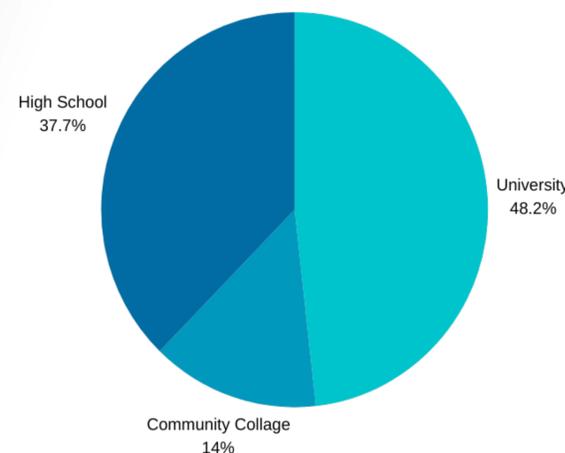
- Q1 checks whether students found the challenges easy to complete
- Q2 checks whether students found the challenges easy to understand,
- Q3 checks whether students had fun solving the challenges.

## High Academia Conclusions

There is a noticeable gap in high-quality educational resources at the university level, similar to the challenges faced at the elementary and middle school levels.

- Studies have shown that educational resources incorporating hands-on components significantly enhance both engagement and efficacy in learning. Yet there is a lack of widespread hand-on components (Deng et al., 2018; Soceanu et a. 2017).
- Implementing targeted educational methods, including diverse learning strategies and teaching models, has been proven to improve learning outcomes (Tsado, 2019).
- Currently, there is a lack of comprehensive models for cybersecurity education certifications (commonly referred to as 'Certs') at the university level. However, there is a growing development of independent 'Certs' and pedagogies aimed at effectively educating university students in cybersecurity.<sup>15</sup>

## Lack of Hands-on Experience in Cyber Security Programs across Academia



## K-12 Conclusion

There is a lack of literature emphasizing on cybersecurity education among elementary and middle school students.

This literature review suggests that there is limited resources and tools implemented among these student groups—potentially inhibiting the number of students gaining interest in this area, and in turn, the cybersecurity workforce.

- Eliminating mathematical concepts not feasible for middle school students may be an approach to employ in an effort to introduce cybersecurity concepts considering that many algorithms use concepts such as finite fields and modular arithmetic (Percival et al., 2022).

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