Board 152: Utilizing Culturally Responsive Teaching Strategies to Enhance the Learning of African-American Middle School Girls in Cybersecurity

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As the risk of cyberattacks increases, the demand for cybersecurity professionals also rises. There are approximately 750, 000 unfilled cybersecurity jobs in the U.S, and 3.5 million global cybersecurity job vacancies (Morgan, 2023). Academia and the technology industry have increased their recruitment efforts to address the growing demands in cybersecurity. Realizing that it did a poor job recruiting women in cybersecurity in other tech areas (Maurer, 2019), the technology industry undertook diligent initiatives to attract and maintain women in the cybersecurity sector, increasing the percentage of women in the cybersecurity workforce to 24%. When examining race and ethnicity within the cybersecurity workforce, 4% of cybersecurity workers self-identify as Hispanic and 9% as African American (Aspen Digital, 2021). When considering African American females in the cybersecurity workforce, the number is significantly low given that African American females only constitute 1.6% of scientists and engineers (National Science Foundation, 2017).

To attract African American females to the cybersecurity field, the Cybersecurity Assurance and Policy (CAP) Center faculty at Morgan State University (MSU) created the Females Are Cyber Stars (FACS) Summer Program (Bailey et al., 2023). The primary objectives of the program were to increase the interest of African American female students in cybersecurity and offer exposure to the fundamental concepts of cybersecurity. This initiative specifically focused on female African American students enrolled in Baltimore City Public Middle Schools. The students ranged from ages eleven to fourteen and were enrolled in grades six through eight. The FACS program was initially introduced in the summer of 2021 and continued to be provided for three successive summers. A total of 39 girls participated in the two-week half day virtual program in the summer of 2021; 25 girls completed the one-week full day in-person program in the summer of 2022; and 23 girls engaged in the two-week half day in-person program in the summer of 2023. Total contact hours for all three iterations of the camp were the same. Bailey et al. (2023) provides a complete description of the 2021 and 2022 implementations.

The FACS program curriculum focused on six cybersecurity concepts: Confidentiality, Integrity, Availability, Defense in Depth, Think Like an Adversary, and Keep it Simple. Topics concerning online safety, cyber ethics, and digital ethics were also discussed. Each lesson included formative assessments to gauge the students' understanding of the content. Prior to the start of each lesson, students were prompted with questions pertaining to the previous lesson to help students recall key topics. Throughout each lesson, students engaged in various knowledge checks to ascertain whether they grasped ideas presented during instruction. Those knowledge checks included the following:

- Thought provoking prompts embedded at pivotal points in the lesson
- Online flashcards to aid in the retention of information
- Fun and interactive quizzes and polls to assess comprehension
- Exit tickets to ensure key points were retained from each lesson

Each knowledge check provided an opportunity for students to further their understanding and aid in the retention of cyber information to prepare students for a summative assessment.

Culturally Responsive Teachings (CRT) strategies were consistently employed each summer to engage the FACS program participants. Strategies included the use of ethnically matched instructors, culturally relevant imagery and presentations by cyber professionals. Program participants were surveyed before and after the program each summer to evaluate student experiences and gauge changes in their interest in and self-reported knowledge of cybersecurity and computing (Bailey et al., 2023). Participants in the summer of 2021 and 2022 reported gains in interest and knowledge. During the summer of 2023, the implementers desired to determine if the participants' self-reported increase in knowledge correlated with actual gains in cybersecurity knowledge. Therefore, the participants of the 2023 program were given a pre- and post-summative cybersecurity knowledge test, in addition to the standard pre- and post-program surveys. This paper describes the Females Are Cyber Stars (FACS) program's Culturally Responsive Teaching (CRT) strategies, discusses the impact of the CRT strategies on student interest and learning ascertained by the pre- and post- program surveys, and an examination of the influence of CRT

strategies on student learning, as evidenced by the scores on the pre-FACS and post-FACS summative cybersecurity knowledge tests.

FACS Program Culturally Responsive Teaching Strategies

The Females Are Cyber Stars program employed Culturally Responsive Teaching (CRT) methods to enhance understanding and involvement by connecting academic content with students' cultural and life experiences. Gay (2010) posited that students' perspectives and comprehension of the world and self are influenced by their cultural background and life experiences, affecting their identity as learners. Incorporating and highlighting elements of the students' culture during instruction enhances their academic experience. Educators who recognize and appreciate a student's cultural background help foster increased acceptance, greater effort towards achieving goals, and active participation in the school environment (Fuhrman, 2020).

CRT strategies are based on the Culturally Responsive framework, which revolves around creating an educational setting that affirms students' cultural identities. The aim is to promote positive academic outcomes, enhance students' ability to connect with diverse backgrounds, amplify the voices of historically marginalized groups, empower students to initiate social change, and contribute to individual engagement, learning, growth, and achievement by fostering critical thinking skills (Framework, n.d). Dr. Gloria Ladson-Billings' research revealed that teachers who implemented strategies to nurture positive cultural and ethnic identities, raise awareness of social injustices, and encourage academic excellence positively impacted classroom performance (Muñiz, 2019). Dr. Ladson-Billings' work serves as a foundational influence that has shaped contemporary perspectives on the necessity for equitable and inclusive instruction in the classroom (Parker, 2022).

Culturally Responsive Teaching (CRT) methods were integrated across various aspects of the FACS program, including instruction, academic activities, classroom management, and staff-student interactions. The goal of incorporating CRT strategies was to create a link between students' cultural backgrounds and life experiences, aiming to enhance understanding and engagement. These strategies involved the use of instructors, student facilitators, and professional speakers who matched the ethnic diversity of the students. Additionally, social and emotional needs were addressed through empowerment activities, daily exposure to prominent African-Americans in STEM, and the integration of visual aids featuring African-Americans to help increase a sense of connection or belonging to the content.

To ensure that students in the FACS program received the best possible learning experiences, instructors, facilitators, and professional speakers were carefully selected to mirror the demographic characteristics of the student body. Numerous studies have shown that educators of the same racial background as their students tend to yield more positive academic outcomes, including improved standardized test scores, attendance rates, concurrent course performance, and reduced suspension rates (Mendenhall, 2020). The instructors and facilitators chosen for the FACS program possessed the ability to understand and connect with the societal and personal experiences of the participants. Evidence suggests that disparities in academic achievements may arise when there is a mismatch in racial or ethnic backgrounds between students and teachers (Grissom, Kern, & Rodriguez, 2015).

Students were introduced to accomplished African-Americans, both through daily lessons and a structured professional lecture series, who excelled as experts, leaders, and entrepreneurs in the STEM field. Incorporating the groundbreaking contributions of Black scientists into educational curricula nationwide will stimulate the curiosity of young children, encouraging exploration of STEM topics (Sharman, 2023). Moreover, daily empowerment activities were implemented to address participants' social-emotional needs, such as self-confidence and self-esteem. Okeke-Adeyanju et al. (2021) concluded that high self-esteem and a positive racial identity have been associated with academic success, behavioral adjustment, and positive emotional well-being for African American youth.

The FACS program further addressed the social and emotional needs of the participants by incorporating images featuring African Americans into its instructional materials. Deliberately choosing images for instructional use can significantly impact the overall classroom culture. When students encounter lessons that reflect their own identities, they become more invested in the learning process (Aguirre, 2020). Furthermore, FACS instructors designed activities that drew on students' existing knowledge of a subject and connected with their personal experiences to create a meaningful bond with the material and their peers. As Gay (2018) suggests, educators enhance their effectiveness by integrating their own and their students' previous experiences, community contexts, cultural backgrounds, and ethnic identities into their teaching approaches. The implementation of CRT strategies within the FACS program contributed to creating an academic environment that was both inclusive and intellectually demanding for the students.

Impact of Culturally Responsive Teaching Strategies

For three consecutive summers starting from 2021, the faculty at Morgan State University's Cybersecurity Assurance and Policy (CAP) Center implemented the Females are Cyber Stars (FACS) Summer Program. The primary objectives of the program were to cultivate interest in cybersecurity among African American female students and to provide them with exposure to the fundamentals of cybersecurity. Specifically designed for female African American students in Baltimore Public Middle Schools, the initiative attracted 39 participants in the virtual program in the summer of 2021, 25 in-person participants in the summer of 2022, and 23 in-person participants in the summer of 2023.

The Females are Cyber Stars program participants in all three summers were given pre- and post-program evaluation surveys at the beginning and end of the program to assess student experiences and changes in their interest in, and self-reported knowledge about, cybersecurity and computing (Bailey et al., 2023). Data were analyzed using IBM Statistical Package for Social Sciences (SPSS) to compute descriptive statistics such as percentages. Program participants in all three years reported gains in interest and knowledge. Overall, with each successive year of the Females are Cyber Stars program, more girls have reported gains in interest in cybersecurity and computing. Comparing their pre- to post-program responses, the percentage of girls who gained interest in these topics over the course of the program went from 40% to 69% to 85% in the first, second, and third years of Females Are Cyber Stars, respectively.

In another measure of interest, we asked girls how likely they were to seek further engagement with cybersecurity and computing in the next six months by talking about it, looking for more information, pursuing further education in and out of school, or seeking information about jobs. Again, as shown in the table below, the pattern has been one of increased likelihood of seeking further engagement with cybersecurity topics.

Table 1

Likelihood of Engaging with Cybersecurity & Computing in the Next 6 Months

	% Somewhat or Very Likely		
	2021	2022	2023
Talk to someone about cybersecurity & computing	40%	44%	69%
Look for more information about cybersecurity & computing	40%	57%	79%
Attend another camp or after-school program about cybersecurity & computing	40%	44%	47%
Take classes that my school offers in cybersecurity & computing	40%	44%	58%
Get further education or training after middle school about cybersecurity & computing	40%	52%	58%
Look for more info about jobs that people can have in cybersecurity & computing	40%	57%	63%

Note. In 2021, the program was virtual due to the pandemic. In 2022, the program was one week of full days. In 2023, the program was two weeks of half days.

Starting in the second year (summer of 2022), we added items about the girls' experiences of the CRT strategies used in the Females Are Cyber Stars program. As shown in Table 2 below, in both years these items appeared on the survey, all or most of the girls 'agreed' or 'strongly agreed' with all 15 items about culturally responsive teaching practices.

Table 2

Experiences of Culturally Responsive Teaching Practices

	% Agree or Strongly Agree	
	2022	**2023**
The program instructors, staff, & administration understand & respect cultural differences.	100%	100%
Diverse identities are represented in the lessons & activities.	96%	84%
Participants are free to share concerns & pressing issues.	96%	94%
I feel that the instructors use creative ways to teach lessons.	83%	74%
I feel that instructors use words that I understand & relate to in order to teach lessons.	96%	100%
I feel that participants are treated fairly.	91%	83%
I feel that the instructors believe that all participants can learn & they make an effort to ensure that all participants do learn.	100%	94%
It was motivating to see others who looked like me.	87%	94%
It was inspiring to see women who looked like me in positions of power & influence.	92%	94%
I was given help when I didn't understand.	100%	95%
I was recognized for my strengths.	84%	89%
The personal development activities helped me to gain confidence & improved my self-esteem.	83%	79%
My instructors speak about contributions that my culture has made to cybersecurity & computing.	100%	94%
My instructors communicate with my parents about what I am learning.	73%	79%
My instructors use what I already know about cybersecurity & computing to help me understand new ideas.	82%	85%

Note. In 2022, the program was one week of full days. In 2023, the program was two weeks of half days.

Assessing Student Learning

In terms of self-reported learning, 100% of the girls in 2021, 78% in 2022, and 84% in 2023 reported learning 'a lot.' Comparing their pre- to post-program self-reported knowledge, most of the girls showed at least some gains over the course of the program: 80% in 2021, 87% in 2022, and 89% in 2023.

There were statistically significant gains in self-reported knowledge in all three years: 2021[1]: $t(9) = -4.8$, $p < .001$; 2022: $t(20) = -5.4$, $p < .001$; 2023: $t(16) = -5.8$, $p < .001$.

In order to gain a more objective assessment of these self-reported knowledge gains, in the summer of 2023, we created a summative cybersecurity knowledge test that was administered at the beginning and at the end of the Female Are Cyber Stars program. The test was created by a cybersecurity faculty member. For an initial content validation, the test was reviewed by a K-12 curriculum expert. Administering the test to the 2023 cohort allowed us to collect data for further validation, as discussed in more detail below. The test consisted of various content areas covered throughout daily lessons for the duration of the program. Topics including Integrity, Defense in Depth, Cyber Ethics, Cryptography, Online Safety and Digital Citizenship were amongst those content areas assessed through the use of fill-in-the-blank, multiple choice, and true/false question prompts. Data were analyzed using SPSS to compute descriptive statistics such as percentages. To assess changes on the summative cybersecurity knowledge test, we computed paired (repeated-measures) t-tests to see if there were statistically significant differences between participant scores before and after the FACS program.

In terms of validity, the fill-in-the-blank and multiple-choice sections of the test did not discriminate well. The fill-in-the-blank items appeared to be too difficult, with scores ranging from only 0-37% correct even after the program, while the multiple-choice items seemed to be too easy, with scores on four of five items ranging from 61-86% correct, even at the beginning of the program. Next year, we will refine the test by deleting these sections. Data collected during the upcoming session will allow further refinement of the test.

[1] Note that in 2021, we used a retrospective pre-test (RPT) approach, in which participants filled out surveys at the end of the camp and self-assessed their knowledge both before and after participation. Research reviewed by Klatt and Taylor-Powell suggests RPT items are more valid than traditional baseline pre-test items in that they are more consistent with objective and behavioral measures of the same constructs without being any more susceptible to biases such as social desirability or demand, but may be susceptible to effort justification bias. However, converging evidence from the objective cybersecurity knowledge test lends credence to the RPT approach to self-assessing knowledge.

Table 3 below shows the girls' performance on the true/false items. For the girls whose pre- and post-program tests could be matched (n = 14), the average scores were statistically significantly higher at the end of the Females Are Cyber Stars program (7.8 correct, vs. 6.1 correct at the beginning): paired $t(1,13) = -2.5$, $p = .013$. Thus, the objective measure of cybersecurity knowledge confirms participants' self-assessments of knowledge gains.

Table 3

Percentage Correct on True/False Items: 2023 Cohort

	Pre (n=18)	**Post** (n=19)
Think like an Adversary doesn't help securing a system? (F)	61%	84%
Defense in Depth is an approach to cybersecurity in which a series of defensive mechanisms are layered in order to protect valuable data and information. (T)	61%	95%
A firewall is like a front door. (T)	56%	95%
A Virtual Protection Networks (VPN) helps secure the systems. (F)	22%	11%
Digital Citizenship is about using technology in a safe, responsible and appropriate way that promotes positive online interactions. (T)	71%	100%
Being a good digital citizen involves: Respect, Safety, Unlawfulness. (F)	28%	42%
Cyberbullying is when someone is threatened, harassed, humiliated, embarrassed or otherwise targeted by another individual in the digital world. (T)	89%	100%
A digital footprint is a trail a person leaves every time they are online. (T)	89%	100%
The internet of things, or IoT, refers to the billions of physical devices around the world that are not connected to the internet, all collecting and sharing data. (F)	11%	63%
Cybersecurity is the practice of not protecting systems, networks, and programs from digital attacks. (F)	72%	95%
Mean Number Correct	5.6 correct	7.8 correct

Conclusion

The Females Are Cyber Stars (FACS) Summer Program was established by the Cybersecurity Assurance and Policy (CAP) Center faculty at Morgan State University to help address the underrepresentation of women and minorities in the cybersecurity workforce, particularly African American females. The program successfully engaged participants for three consecutive summers, utilizing Culturally Responsive Teaching (CRT) strategies and a curriculum that focused on key cybersecurity concepts. The FACS program increased interest in and knowledge of cybersecurity among African American female students. The program also demonstrated the positive impact of CRT strategies on their learning experiences. The program's success, as indicated by pre- and post-program surveys and a summative cybersecurity knowledge test, highlights the importance of inclusive educational initiatives in addressing the diversity gap in the cybersecurity field and fostering a more representative and skilled workforce for the future.

Future Work

We aim to develop an improved way to gauge the students' cybersecurity knowledge. The fill-in-the blank questions on the summative cybersecurity knowledge test posed some difficulty for the students, and the multiple-choice questions seemed too easy. The outcomes of both the surveys and summative tests reveal that the implementation of Culturally Responsive Teaching (CRT) strategies within the FACS program positively impacts the enthusiasm for and comprehension of cybersecurity among African American female students. Therefore, we plan to incorporate more CRT strategies such as familial engagement. As it stands, parents are only engaged during the recruitment process and the first day of camp. A few activities during future iterations of the program will include parents. These activities may be completed at camp and/or at home. We also plan to recruit more industry partners to provide students with real-world problems to solve and an opportunity to form relationships with cybersecurity professionals.

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