A Cyber Bridge Experiment

Mary Ann Hoppa
Computer Science
Norfolk State University
Norfolk, Virginia USA
mahoppa@nsu.edu
0000-0002-6103-7814

Abstract—This paper describes the design, implementation and first delivery of a no-cost, no-credit, multi-week virtual bootcamp called *Cyber Bridge*. The motivation underlying Cyber Bridge is to cast a wider recruitment net by easing the transition of students – especially those from non-technical academic preparations – into cybersecurity studies, particularly at the graduate level. It provides background insights regarding the inception and evolution of the *Cyber Bridge* project, experimental methodologies and observations, and findings based on analysis of collected metrics and feedback. Results support the view that a *Cyber Bridge* is a reasonable approach to: increasing students' comfort level regarding virtual learning environments; introducing and reviewing some cybersecurity foundations; connecting students to additional resources to improve upcoming academic experiences; and moderating their confidence by recognizing knowledge gap areas they may need to review or remediate. Future direction ideas and recommendations are shared that align with a longer-term vision to mobilize this capability to empower more underrepresented, underserved individuals to succeed as cybersecurity professionals and researchers.

Keywords—*cybersecurity, upskilling, student outcomes, retention*

I. INTRODUCTION

Cybersecurity labor and skill gaps are well publicized and exacerbated by a general insufficiency in the number of STEM-qualified graduates and working professionals. To meet industry needs, a wider net must be cast to recruit talented individuals from both Information Technology (IT) and non-IT backgrounds and upskill them to work in this important field.

Even though most people use digital capabilities on a daily basis, familiarity as a user is far different from understanding the underlying technologies, particularly in degree-and certification-seeking contexts. The more digital awareness individuals can acquire ahead of time, the better positioned they are to succeed in cybersecurity and related fields.

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Norfolk State University's (NSU) Master of Science in Cybersecurity (MS.CYB) program recognizes that non-traditional students (e.g., first-generation college students, career switchers, those returning to college after a hiatus, military veterans, retirees) and students who have non-technical undergraduate preparations all can be valuable to growing and fostering innovation within the cyber workforce of the future. While some students enter NSU's program along traditional Computer Science (CS) and IT educational and experiential paths, many others come from unexpected directions, such as music, healthcare and social work, to name just a few. Often students are seeking to transition into more lucrative cyber careers, or to pursue lifelong passion areas.

This report documents the development and first delivery of a no-cost, no-credit, multi-week virtual bootcamp called *Cyber Bridge* at NSU. The near-term vision for the *Cyber Bridge* is to help ease the transition of NSU students – specifically those newly admitted to the MS.CYB program – into their cybersecurity graduate studies. As a longer term vision, the *Cyber Bridge* could serve as a stepping stone for many underrepresented and underserved individuals to become more competitive academically and professionally in the cybersecurity industry, whether through scholarly achievements, certifications, experiential learning or career networking.

The remainder of this paper is organized as follows. Section II presents background information, and Section III presents related work, both of which motivated the project. Section IV explains methodologies used for the experiment. Section V discusses findings. Section VI gives a summary recap and suggests ways to build upon this work.

II. BACKGROUND

A. NSU Overview

NSU is a comprehensive urban, public, Historically Black College/University (HBCU) established in 1935. The university is committed to offering rigorous academic programs, and a supportive culturally diverse learning environment. As one of the most affordable four-year public institutions of higher education in Virginia, NSU provides opportunities and access to a globally competitive education, preparing students to compete in the 21st century workforce. The student body is comprised of about 5,000 undergraduate and 500 graduate

students, with a 2:1 ratio of students identifying as female versus male.

B. *Cybersecurity at NSU*

NSU launched its all-online MS.CYB program in 2015. The program is comprised of a fixed curriculum of 12 three-credit-hour courses. The last two of these courses are a capstone experience in which students apply what they have learned to investigate a cybersecurity issue or problem and to make recommendations for improving cybersecurity practices. A unique feature of the program is its commitment to increasing diversity in the industry by admitting students who have earned bachelor's degree in virtually any discipline seeking to transition into cybersecurity. In any given cohort, at least half the students come from non-STEM background preparations. To date, such admissions have proceeded on a "sink or swim" basis. This can be a steep climb for students who lack formal technical training or have limited practical experience. So it is notable that to date some 150 students have earned their degrees, on average 20 per year.

III. RELATED WORKS

The idea of *bridging* diversely prepared individuals to better position them for successful STEM studies including cybersecurity is not new or unique. Examples of such upskilling programs exist at numerous colleges and universities, including NYU Tandon School of Engineering [1], Hampton University Online [2] and Roosevelt University [3] to name just a few. Typical cybersecurity bridges are comprised of introductory-level courses in topics such as networking, operating systems, computer programming and cybersecurity basics; some include discrete mathematics and data structures. They range in duration from one month to a year, and may cover up to 400 hours of learning content.

Alternatively, some schools like Penn State World Campus [4] and the University of Rhode Island [5] have created or repurposed existing certificate programs as on-ramps for students to explore a technical discipline like cybersecurity and to potentially segue into full-on graduate studies. A primary differentiator between NSU's *Cyber Bridge* and these other programs is cost: to take down socio-economic barriers, NSU's *Cyber Bridge* was offered at no cost to participants, with plans to continue at no cost in the future.

IV. METHODOLOGY

The experimental element of this effort sought to gain empirical insight into the extent to which the *Cyber Bridge* could positively impact students': *familiarity* with relevant technical topics; awareness of helpful resources; and *confidence* in their potential for academic success.

In addition, this effort sought to explore how participating in a virtual bootcamp style learning experience including onboarding and technical materials would impact student outcomes and in-program retention. Thus *Cyber Bridge* participants were considered the *experimental group*; whereas the *control group* was comprised of students already in their second semester or later in the MS.CYB program, and recent graduates (MS.CYB conferred in May 2020 or later). In other words, the control group never had the benefit of the *Cyber Bridge*.

The following stepwise procedures were followed to investigate these questions in the context of NSU's cybersecurity graduate program.

1) *Designed the Cyber Bridge curriculum.*

Topics were selected by the cybersecurity graduate program coordinator based on knowledge/skill gaps observed among NSU's MS.CYB students over the past seven years.

2) *Implemented the Cyber Bridge curriculum as an online organization using NSU's eLearning platform Blackboard (Bb).*

Implementing the *Cyber Bridge* as a Bb organization helped to position it for potential future use by individuals who have not yet applied/enrolled in an NSU degree program (i.e., do not have a branded email yet), and/or by individuals at peer institutions.

Pre-existing public domain and NSU-generated content was used to populate the *Cyber Bridge*. Each item was marked with an estimated time to complete it. Content included a mix of reading/viewing material and a few hands-on activities (e.g., PwC's Virtual Cybersecurity Consulting Experience) to suit diverse learning styles. The *statistical tracking* feature was enabled on each Bb item to monitor participants' content views.

A subset of the material was earmarked as *required* or *recommended* for all learners. The estimated total time commitment for reading/viewing required material was 20 hours. A few more time-consuming activities (e.g., learn the basics of a programming language) were earmarked as *optional*. This was done to give participants some choices about which items to complete in relation to the time they had available to invest.

3) *Invited all Fall 2023 cohort students in NSU's MS.CYB program to engage in the Cyber Bridge.*

The bootcamp period lasted from 17 July through 13 August 2023, that is, one month prior to NSU's Fall 2023 semester launch. Historically, it is difficult to get online learners to complete learning activities that do not have course "points" or college credits associated with them, even when those activities could be of personal or professional benefit to them. So students who joined the *Cyber Bridge* were awarded a $50 Amazon gift card as an incentive, to be distributed at the end of the month-long engagement period.

These experimental group participants were encouraged to visit Bb areas in the order listed in the curriculum, and to complete the required items in each area in-order as well. However, students were not *forced* to visit content nor to do so in a prescribed order through any automated means (such as Bb *release rules*). Instead, all areas of the Bb were open to

all participants throughout the four-week bootcamp period; and during that time participants could invest as much or as little time in whichever areas they chose.

The experimental group remained enrolled in the *Cyber Bridge*, and it was accessible to them throughout the Fall 2023 semester. This meant they optionally could continue to review content or spend more time on deeper dive topics – like learning a programming language or certification activities – until the Bb closed on 31 December 2023. Taken together, these rules of engagement supported the principle that *Cyber Bridge* participation was voluntary, and intended to let students decide which topics most interested them, which topics they believed they needed to review, and how much time to invest.

4) *Collected "360 feedback" from students via qualitative, self-reporting surveys.*

Surveys were used to qualitatively probe the extent to which the *Cyber Bridge* impacted the experimental group's: *familiarity* with specific topics relevant to cybersecurity; *awareness* of resources available to help them to be successful academically and professionally; and *confidence* about completing their degree. As pointed out earlier, these considerations had been used to form the research questions and the content included in the *Cyber Bridge*; they likewise align with academic and professional success in cybersecurity. Additional open-ended survey questions were included to collect suggestions about potential opportunities to improve the *Cyber Bridge* and/or NSU's MS.CYB program in the future. Individual students' survey responses were anonymized (identifying information removed), combined with others, and summarized (averaged) to protect their privacy.

Experimental group survey responses were collected immediately before, then again immediately after, their bootcamp experience and are referred to as the *baseline* and the *benchmark*, respectively. These data allowed qualitative assessment of average changes in participants' familiarity, awareness and confidence. Participants also were asked to respond to questions about the extent to which they had explored the various content, activities and resources available in the *Cyber Bridge* at benchmark time. These data were compared to the automated usage statistics collected within Bb and sampled at the end of the four-week bootcamp period. This supported comparing how thoroughly the participants *believed* they had explored the *Cyber Bridge* materials, versus their *actual* Bb tracked content visits.

Control group survey questions were similar to the experimental group baseline/benchmark survey questions. This supported comparing familiarity, awareness and confidence as self-reported among experienced students versus the newly admitted experimental group students; and collecting more suggestions about ways to improve the *Cyber Bridge* experience.

5) *Sampled in-curriculum performance and retention for Fall 2023 cohort students who engaged in the Cyber Bridge versus those who did not.*

Data were pulled from student transcripts, and were binned and analyzed per the following sample populations: (1) *Cyber Bridge* participants from the Fall 2023 cohort; (2) non-participants from the Fall 2023 cohort; and MS.CYB students from the prior academic year, that is, Fall 2022 and Spring 2023.

These data were scrutinized to look for any performance and retention differences when comparing new students in the MS.CYB program who had engaged in *Cyber Bridge* versus students in the MS.CYB program who had not engaged in the *Cyber Bridge*. *Learning outcomes* were examined via grades earned in first-semester courses. *Retention* was assessed based on whether students completed at least the first two courses in the curriculum after being admitted to the program.

V. FINDINGS AND RECOMMENDATIONS

The following findings are based on a single delivery of the *Cyber Bridge* at NSU. It is important to keep in mind that due to the small sample size, observations are qualitative in nature rather than statistically significant. Similarly, the repeatability of results remains to be validated in future experiments involving the *Cyber Bridge* at NSU and beyond.

A. Participation

All 22 students registered to start NSU's MS.CYB program as the Fall 2023 cohort were invited to participate in the *Cyber Bridge*. Participation levels varied and were characterized as follows:

- *no participation* (41 percent);
- *minimal:* some survey responses only (14 percent);
- *moderate:* responded to all surveys and accessed at least half of the learning content (18 percent); and
- *maximal:* responded to all surveys and accessed more than half of the learning content (14%).

B. Content Usage

Table I shows how many students visited each of the 24 content items. Every item was visited by at least three (3) students. The majority of items were visited by one-fourth of the total cohort. The most visited item (Graduate Student Handbook) garnered visits by just under half the cohort; whereas the least viewed item (Consulting) received just three (3) visits.

TABLE I. Visitor Count per Content Area

Onboarding	
Overview	9
Baseline	7
Handbook	10
Policy & Proc	8
Blackboard	6
Other	5

Connections	
Overview	7
Consulting	3
Students	7
Internship	6
Portfolio	5

Jumpstart	
Overview	7
Computer	7
OS	8
CS	8
Pgming	5
Python	5
DB	5
Tech Writing	4
Cyber Sec'y	6
Ethics	5

Assessment	
Overview	4
CertPrep	4
Reminder	5
Overview	4

Based on their engagement survey responses, students in the experimental group reported they spent on average 7.3 hours weekly on the *Cyber Bridge* material; and they believed they at least attempted all the various optional enrichment activities, such as learning Python and creating a Handshake [6] account. Although it remained open throughout the Fall 2023 semester, NO students accessed the *Cyber Bridge* after the bootcamp period.

C. Familiarity, Awareness and Confidence Ratings

Figure 1 shows how the experimental group (participants) self-rated their familiarity with topics related to cybersecurity before starting the *Cyber Bridge* (baseline - blue) and after completing it (benchmark - orange) using a typical Likert scale, where 0 = very unfamiliar; 1 = somewhat unfamiliar; 2 = somewhat familiar; 3 = very familiar. The control group also self-rated (grey).

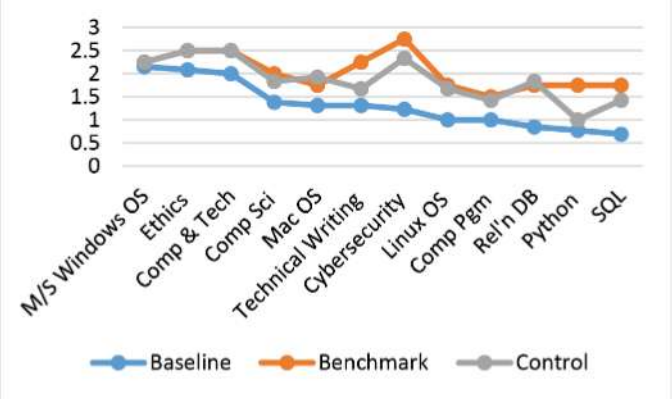

Fig. 1. Topical familiarity comparison

Figure 2 shows how participants self-rated their awareness of NSU resources available to help them during their master studies before starting the *Cyber Bridge* (baseline - blue) and after completing it (benchmark - orange) using a similar Likert scale where 0 = very unaware; 1 = somewhat unaware; 2 = somewhat aware; 3 = very aware.

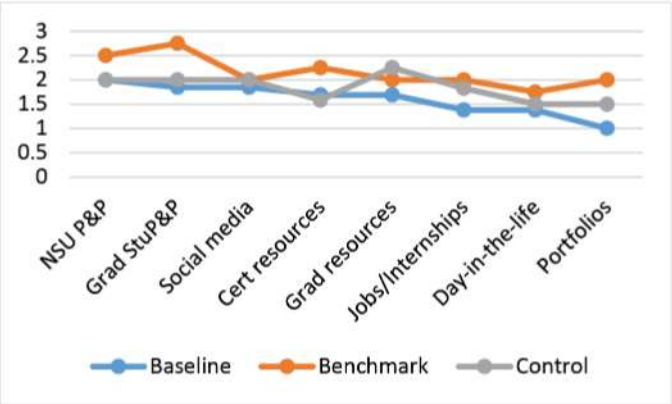

Fig. 2. Resource awareness comparison

The size of the gaps between the two participant plot lines (blue and orange) can be interpreted as a visualization of how much change (learning) occurred. There were positive gains in all areas for both familiarity and awareness. Places where the benchmark plot (orange) dips below the control plot (grey) may reveal areas where the bootcampers still may be underprepared. Places where the benchmark plot (orange) rises above the control plot (grey) may be interpreted to show that *Cyber Bridge* participation has better positioned the experimental cohort – in terms of topical confidence and awareness about useful resources – versus past students who did not have access to this learning experience Examples include Technical Writing, Python skills and Portfolio creation.

D. Confidence in Academic Success

Cyber Bridge participants were asked to self-rate how confident they were overall about starting their cybersecurity studies, using a typical Likert scale where 0 = very unconfident; 1 = somewhat unconfident; 2 = somewhat confident; 3 = very

confident. The baseline average was 2.38; the benchmark average was 2.00. This drop in confidence might be interpreted as participants realizing that they have some gaps they need to fill to be successful during their upcoming studies. On the other hand, it also may be a simple data artifact. The vast majority of control group respondents had already completed their degree, so their confidence self-ratings were considered not significant.

E. Student Outcomes

The sample sizes in this experiment are too small to derive any statistically sound conclusions; however, it is possible to make some reasonable, though speculative, observations. Inspection of outcomes focused on grades earned in the first two courses of the curriculum which are taken by all MS.CYB students in their first semester. Table II summarizes outcome data based on grades earned in these two courses, where students were placed into outcome categories as follows:

- A: received A grades in both courses.
- A/B: received a combination of A/B grades in the two courses.
- A/F: received an A grade in one course and a non-passing grade (lower than B) in the other course.
- F: received non-passing grades (lower than B) in both courses.
- W: withdrew from both courses during the semester.
- Defer: deferred for up to a year following the initially enrolled semester.

TABLE II. Student Outcomes Summary

Outcome Categories	Fall 2023		AY 22-23
	***Cyber Bridge* Participants**	**Non-participants**	
A	60%	25%	38%
A/B		17%	17%
A/F			8%
B	20%	8%	
F	10%		4%
W	10%		
Defer		17%	4%
Non-start		33%	29%

The first two data columns in Table II give a side-by-side comparison of outcomes for students in the Fall 2023 cohort who were *Cyber Bridge* participants and non-participants, respectively comprising 10 and 23 total students. For Fall 2023 cohort students who did participate in the *Cyber Bridge*, the 80-20 principle applied. That is, 80 percent of them solidly passed their first two courses; while 20 percent received non-passing grades or withdrew early in the first semester.

There were more than twice as many "straight A" students among the *Cyber Bridge* participants (60 percent) versus among non-participants (25 percent). Half of the Fall 2023 cohort students who did not participate in the *Cyber Bridge* ultimately deferred by a semester or never started the program. All remaining non-participants passed both courses with a B or better.

The right-most data column in Table II shows outcomes for MS.CYB cohorts from the prior academic year – Fall 2022 and Spring 2023 – when the *Cyber Bridge* was not available. There were 24 total students in these two cohorts. In this control group the proportion of non-starts (about one-third) is similar to the *Cyber Bridge* non-participants. The proportion of control group students who passed both first-semester courses (about half) with a B or better is similar to *Cyber Bridge* non-participants.

F. Student Retention

It is more difficult to come to conclusions regarding retention. One general remark is that all the experimental students who successfully completed their first semester with passing grades were retained to the second semester. Other factors like economic hardship should be recognized and can be fairly significant at HBCUs: a low GPA and/or academic probation can impact student eligibility to receive financial assistance and therefore retention.

It also should be noted that 80 percent of *Cyber Bridge* participants passed their first semester courses; whereas only around half of the non-participants (from Fall 2022, Spring 2023 and Fall 2023 cohorts) did so. Anecdotally within NSU's MS.CYB program, students who earn passing grades in all first-semester courses are more likely to return for the next semester, and to eventually complete the program. So these data may weakly support the conclusion that *Cyber Bridge* participation positively impacts retention.

G. Open-ended Feedback

Baseline, benchmark and engagement surveys all included open-ended questions that invited the experimental group to share suggestions or concerns about the *Cyber Bridge* or their upcoming studies. Students expressed worries about the availability of financial aid, how difficult the material would be, and someday passing certification courses. Some topics they thought would improve the *Cyber Bridge* experience included addressing ways to connect with other students in the program, professional organizations and employment opportunities. Some believed more in-person learning opportunities would benefit them.

The control group expressed many suggestions similar to the experimental group. They opined that more information about preparing for future careers – including internships, resumes, job searching and mentor arrangements – would be beneficial. Several also suggested adding a topic to the curriculum related to cloud technology and its security issues due to the prevalence of hybrid work environments.

H. Recommendations

Analysis of the metrics and feedback – though from a small number of students and a single delivery – suggest the following principles and improvements for future spirals of the *Cyber Bridge* effort.

Integrating a pre-bootcamp assessment can help students identify and work on individual knowledge gaps and support delivering a personalized learning experience. In a similar way, integrating per-unit exit assessments can provide immediate feedback to participants regarding their knowledge growth, as well as monitoring average levels of mastery in the topical areas. This tangible evidence also could help positively impact students' motivation to continue their *Cyber Bridge* engagement and increase self-confidence about upcoming studies.

Thought also should be invested regarding the conditions under which students may be able to retake the *Cyber Bridge* in case of low mastery scores. Assuming it can be sustained as a free resource, repeat *Cyber Bridge* participation should not pose a problem. In case of resource constraints or automation-driven enrollment limitations, priority should go to first-time enrollees.

Participants appear unlikely to engage in the *Cyber Bridge* during the semester proper when they are taking for-credit courses. This suggests the experience needs to be delivered during breaks or the month leading up to Fall and Spring semesters so it can be completed before students must start their for-credit courses. Subject to available resources, occasional synchronous sessions might be offered on select topics, and recorded for later integration into the *Cyber Bridge* curriculum.

Valuable feedback may be garnered from faculty who teach cybersecurity at NSU and other universities, and experienced cybersecurity professionals. This may help identify existing *Cyber Bridge* topics to adapt or remove; new topics or content to add; gamification features or other motivators that might be integrated to increase student interest and engagement; and potential ways to adapt the *Cyber Bridge* for use with undergraduates and/or high school juniors/seniors.

VI. CONCLUSIONS AND FUTURE DIRECTIONS

A. Conclusions

A relatively small number of students were involved in this short experiment (< 50 students during one semester). It is reasonable to observe that engagement in the *Cyber Bridge* does not guarantee successful student outcomes in the first semester, since there are so many other potentially impactful factors. Prospective students' overall familiarity with relevant topical areas and awareness of resources helpful to their academic success is likely to be positively impacted (increase) by *Cyber Bridge* participation. This experiment also showed that *Cyber Bridge* participation improved student outcomes and indirectly, positively impacted retention.

B. Future Directions

More *Cyber Bridge* deliveries and data collection/analysis, including longitudinal studies, need to be performed in the future over a longer period of time to make stronger, statistically significant claims.

The *Cyber Bridge*, like any prototype, can be evolved to better match the needs of future constituents based on findings and feedback. One path forward is to develop and integrate additional content and activities into upcoming academic year plans, both in the *Cyber Bridge* itself and in relevant undergraduate and graduate courses. A self-assessment instrument could be developed and used to help move beyond a *one-size-fits-most* approach, by personalizing individual student's learning experiences on areas the most in need of review or remediation.

As a longer term goal, the *Cyber Bridge* might be migrated to the mobile app environment where it can be delivered in bite-size chunks, and by adding in gamification motivators to help make a future *Cyber Bridge* even more accessible, relevant and engaging to digital age participants. To have sustained success, resources must be committed to setting up, monitoring, maintaining and evolving the *Cyber Bridge*. Adopting a *freemium* model – with both free and at-cost features – could help to generate a funding stream for further development, as could philanthropic donors and corporate sponsors.

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