# A Virtual and On-site Hackathon to Recruit High School Students within Cybersecurity Major

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***ABSTRACT:*** *Cybersecurity is a rapidly growing field with jobs in high demand, however, it becomes a challenge to inspire high school student interest in the discipline. Traditionally, a hackathon is an event designated to broaden participation and perceptions in computing. It is usually programming-intensive and does not fulfil the features of cybersecurity. Faculty and staff from Gannon University recently designed and implemented an innovative hackathon event which included both virtual and on-site competitions. Student feedback and growth of enrolment demonstrated the program's efficiency and effectiveness under tight-budget circumstances. This paper is an extension of work presented at Frontier in Education (FIE) 2020 and published in its proceedings [1].*

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## 1. Introduction

The importance of and need for cybersecurity has become paramount in business, community and government this last decade. Government agencies including National Security Agency (NSA), Department of Homeland Security (DHS) and Department of Defense (DOD), actively recruit cybersecurity professionals. For example, DOD laid out a plan to lookout for cybersecurity talents [2, 3]. The private sector has been struggling with cyber-attacks even prior to the government, which relies on private entities to help ensure national security [4, 5]. To secure their digital environments, large private firms have significantly increased their budget for hiring cybersecurity talent and providing cybersecurity training for employees [18]. Moreover, the competition and collaboration between private sectors and government are further driving up the market demand for cybersecurity professionals [6, 7]. It is estimated there will be as many as 3.5 million unfilled cybersecurity positions by 2022 [8].

National and state education agencies acted fast to fund initiatives in support of the fast-growing cybersecurity job market. For example, the National Science Foundation (NSF) has funded nearly $75 million for cybersecurity research projects in 37 states. These research projects have helped graduate students in public institutions to gain research experience and skill in cybersecurity [9]. The National Security Agency (NSA) provides guidelines for higher education institutions to be designated as Centers of

Academic Excellence (CAE) in cyber defense and cyber operations [10, 11]. The number of CAE has tripled in the last three years [12]. To follow the trend, Gannon University, a private liberal art college located in Northwest Pennsylvania, started undergraduate Cyber Security and Cyber Engineering programs in 2019. However, from a marketing and recruitment perspective, how to inspire high school student interest in cybersecurity remains a challenge for small liberal art institutions like Gannon University due to the limited budget.

In this article, we argue that small institutes can adopt hackathons as great vehicles to raise interest in cybersecurity among high school prospective students. A hackathon is a programming competition event, usually hosted by a tech-firm or university, where programmers work for a short period of time to complete a project [19, 20]. During a typical hackathon competition, programmers are organized in teams and work together to complete a programming challenge. A hackathon event generally lasts one or two days over a weekend. At the end of the event, a winning-team is announced and awarded [19, 20]. Due to their participatory and competitive nature, hackathons are considered a successful solution to student recruitment challenges. The success has encouraged many public universities to adopt hackathons to stimulate prospective students' interest in cybersecurity. They have become host bases for national or regional cyber competitions. For example, some success stories have been reported by schools hosting CyberPatriot, which is a National Youth Cyber Competition by the Air Force Association [15, 16]. However, for small liberal art colleges like Gannon University, there are several difficulties in adopting hackathons as recruitment methods. Traditional hackathon events require long-term implementation, usually years, to build networks with local high schools. They do not fit well with universities like Gannon in which cybersecurity programs are in their infancy. More importantly, as recruitment methods, programming contests or national competitions were not optimal. The major concerns for recruitments are:

1. The event or campaign is expected to be broadcasted as much as possible for marketing purposes;

2. It needs to be cost effective because of limited funding resources;

3. Only one winner is feasible due to the rare scholarship incentive from the University. Other related problems such as how to connect with high school students efficiently, are also addressed during the design phase of the project;

To overcome the limitations of traditional hackathons, Gannon university has built an innovative approach combining both virtual and onsite hackathons to recruit high school students interested in a Cybersecurity Major. The virtual hackathon was developed based on Open Web Application Security Project (OWASP) Juice Shop, which is an open-source insecure web application. Students are expected to deploy and "hack" their own website. The virtual event provides maximal broadcasting for Gannon's new major. Global and domestic high school students get the opportunity to experience being a "hacker." Scores are calculated on the difficulty of hacking tasks. The on-site hackathon is a one-day event to allow students and parents the opportunity to "meet the professors" as well as participate in cyber testing and class lectures. Special topics in cybersecurity are introduced during the on-site event. In an interactive lecturing environment, students are exposed to advanced topics such as penetration testing and network security. Students also have opportunities to meet invited cybersecurity experts from industry.

## 2. Virtual Hackathon

The first part of Gannon Cybersecurity Hackathon is virtual-based. The virtualization approach can maximize the impact of the event and the number of attendees. It allows students from various geographical locations to join the event. The non-traditional setup also helps raise interest to high school students. Minimized software or hardware requirements during the virtual hackathon attempt reduces the potential technical burden for inexperienced users. Digital formats reduce the cost of communication and marketing, especially during the coordination of the event. The integration of cloud services also provides an opportunity to impress students with modern technology.

In preparation for the virtual hackathon, the infrastructure of competition was closely studied. Traditional network intrusion or defense projects are usually expensive and difficult to transfer into virtualization. For example, virtualization of a customized operating system image in Amazon Web Services (AWS) costs users financially and technically and this goes against our vision. The comprehensive security monitoring system from Amazon also can put the event at risk. Even though we test our project on a smaller scale with several instances successfully, it is possible that Amazon would block the activities when a security breach is at the national or global level. Similar risks are applicable to other Cloud services providers. Topics in cybersecurity such as digital forensics, are also considered unrealistic.

An approach based on OWASP Juice Shop was adopted into our virtual hackathon. OWASP is a non-profit foundation that works on improving the security of software. OWASP Juice Shop is one of the most modern and sophisticated insecure web applications. It is commonly used in security training, awareness demos, Capture-The-Flag (CTF) and as a guinea pig for security tools. The Juice Shop project encompasses vulnerabilities from entire OWASP top ten software along with many other security flaws found in real-world applications. To fit the open-source project into our requirements, some customizations were applied. The simulated business was changed from a juice shop to Gannon University's gift shop. The web page background color was modified to that of the University's color and several products with the Gannon University motto now appeared on the "gift shop" webpage. The test bank was updated.

The OWASP Juice Shop project provided a comprehensive list of challenges with different levels of difficulty. The difficulty is marked from one star to five stars. A one-star challenge usually means an easy one where a five-star challenge means a task needs deep understanding of web vulnerabilities and usually requires programming skills. Since our users are high school students, only four one-star challenges and two two-star challenges are picked. A related scoreboard webpage is updated and users can observe their achievements. The customized project is packed and deployed into GitHub.

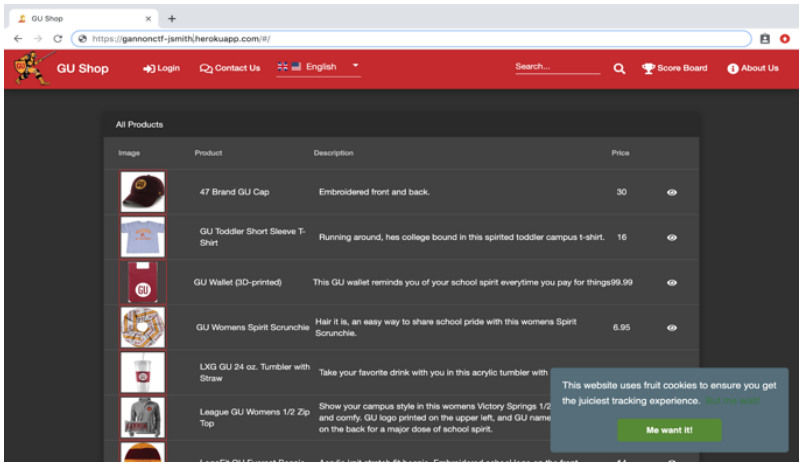


Figure 1. Screenshot of Gannon Cybersecurity Virtual Hackathon Webpage

The logistics of a virtual hackathon are as follows. Attendees have three hours to finish the virtual hackathon. After filling necessary information, such as names and email addresses, students need to build a Heroku account. Then, they follow our GitHub URL to deploy their own insecure website. Following the provided instructions, high school students will "hack" the website with two easy challenges. It is also a process for them to be familiar with our virtual hackathon challenges and related submission system. Then, students are expected to focus on provided challenges. The deployed website is a Capture-The-Flag environment. That means, a banner will pop-up on the website once a challenge is achieved. Related hash code for the key is demonstrated. Students are expected to submit hashed keys through an emailing system. During the whole process attendees only need a computer with internet services and an email address. Since Heroku is a free platform as a service (PaaS), attendees do not need to spend anything for their account. The Cloud Computing technology provides an operating system independent environment and stays consistent with our vision above, which is to minimize the software or hardware requirement for attendees.

Two technologies are introduced in the virtual hackathon. High school attendees learn to deploy a website through Heroku and the experience shows them how easy it is to have a website in cloud service. It is a different approach to inspire student interest with website development, rather than focusing on coding HTML or JavaScript. By hacking their own website, it makes our young students feel like a "real hacker," but in a safe way. Both educational goals are achieved during the virtual hackathon. Firstly, students are expected to install a virtualization environment by following installation instructions. This is an important yet basic skill for being a cybersecurity professional in general. The second goal is to encourage critical thinking. Given a new cybersecurity challenge, finding a solution quickly and thinking outside the box are skills used in the study of cybersecurity and related computer science disciplines. Due to the nature of virtual events, students are expected to look for technical solutions online. We consider the ability to get help through online resources as essential for high school students to understand their future career.

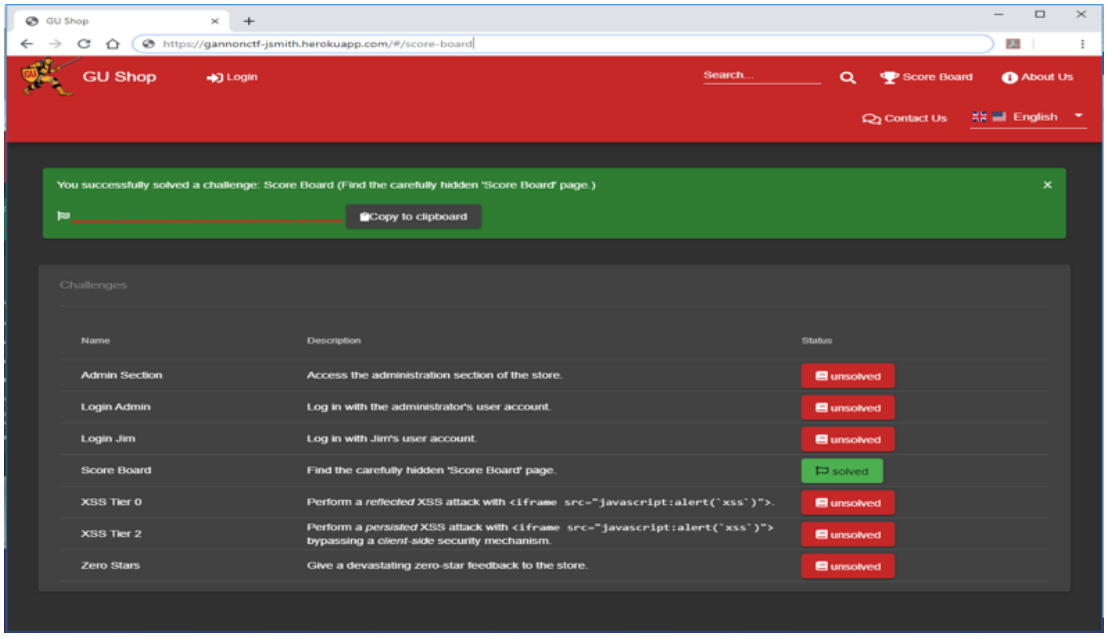


Figure 2. Screenshot of Gannon Cybersecurity Virtual Hackathon Scoreboard Webpage

## 3. On-site Hackathon

After the virtual hackathon, top performing students are invited to Gannon University for the on-site hackathon. Only students located within driving distance accepted the invitations. Besides participating in the event, the on-site hackathon allows high school students to "meet with professors" and tour the campus. The major motivation of on-site hackathon is student recruitment. Of course, the on-site hackathon provides opportunity to demonstrate and practice projects for smaller groups.

The logistics of on-site hackathon are as follows. In the morning, two lecturing sections are delivered by the cybersecurity faculty. Each lecture is about 75 minutes. The first section covers fundamental concepts about cybersecurity, including history and definition of cybersecurity, types of hackers, security ethics, and related career paths. More videos and interactive teaching methods are integrated in the first section. The second section emphasizes the hands-on project. Specific web intrusion techniques, such as Cross-site Script (XSS), Cross-site Request Forgery (CSRF), and SQL Injection are explained. The webpage from the virtual hackathon is used as a practice platform. It is easy for faculty and students to start a project from the same page. Lunch is provided by Gannon to the students and parents. During lunch time, a local cybersecurity expert is invited to give a presentation about the cybersecurity business and job marketing. In the afternoon, a test is given to the students to determine the winner of the university scholarship. The test is primarily in a multiple-choice format. It simulates a professional cybersecurity certification exam. The test includes three parts: 1) content introduced in the morning sections, 2) fundamental concepts in computer science (similar to the CompTIA A+ certification exam), and 3) fundamental concepts in cybersecurity (similar to CompTIA Security+ exam). Students are expected to finish 90 questions in one and a half hours. After the test, students and parents are taken on a campus tour, and a ceremony is hosted for all participants at the end of day.

## 4. Hackathon Results

In 2019, Gannon University hosted two sections of virtual hackathon. In 2020, Gannon hosted four sections of virtual hackathon. A total of 255 high school students registered for the virtual hackathon. 178 of them attended the following on-site hackathon event. 160 finished and submitted their test answers in the on-site event. The geographical distribution of high school students included 13 states with the majority located on the east coast of the U.S. Students from Virgin Islands and Puerto Rico also joined the competition. More than two-thirds of the students were first-time contacts for Gannon University.

The grade of the virtual hackathon project ranged from 0 to 1000 points. Student performance distribution is shown above [Fig. 3]. 23% of students logged into the system but gave up after reading the installation instructions to set up a website in a secure

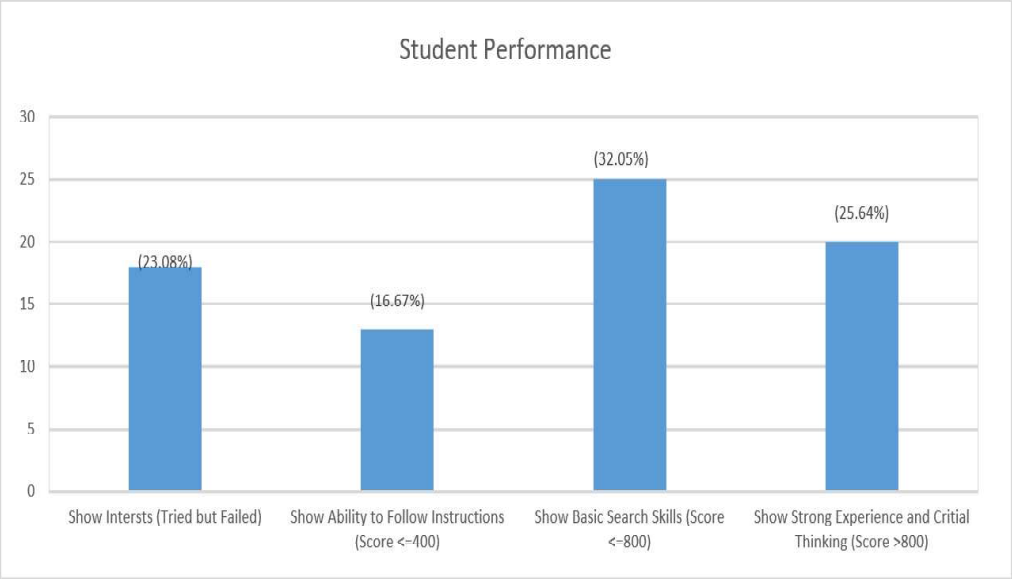


Figure 3. Student Performance Distribution on Gannon Cybersecurity Virtual Hackathon

virtualization environment named Heroku. 17% of students followed the instructions, deployed the website in Heroku, and attempted to "hack" the website. No further progress was performed in the "open" questions, however. About 32% of students showed basic online search skills and solved some easy challenges. More than 25% of students finished the medium level challenges. These individuals are considered to have some background in cybersecurity or computer science and can find complicated solutions.

After the virtual hackathon a survey was provided to each student to collect their feedback. The survey is a combination of marketing and feedback questions. Figures 4 – 6 provide examples of questions asked with student feedback results on their virtual hackathon experience.

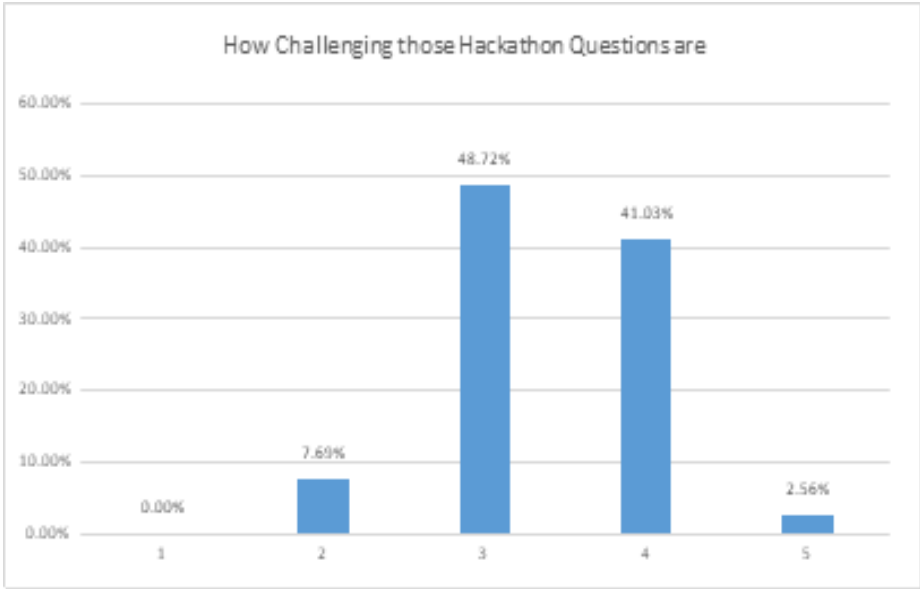


Figure 4. Student Feedback on the Difficulty of Challenge Questions in Virtual Hackathon

One of our concerns was whether the challenges fit the knowledge base of the high school students. The difficulty is rated from 1 to 5. One is easiest and five is the most difficult level. On Figure 4, the majority of students considered the challenge questions in the virtual hackathon to be adequate or a little difficult.

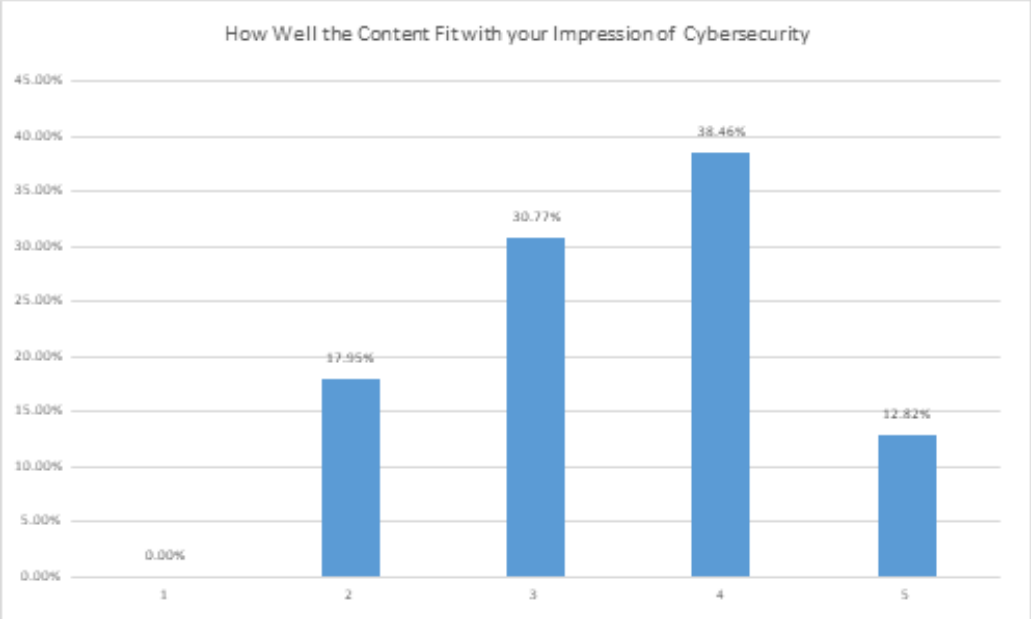


Figure 5. Student Feedback on the Fitness of Cybersecurity Theme in Virtual Hackathon

Another concern was whether the format of virtual hackathon fit with students' understanding of cybersecurity. The level of fit is rated from 1 to 5. One is not fit at all and five means fit exactly. Based on Figure 5, the majority of students consider the format and topics in virtual hackathon fit with their impression of cybersecurity.

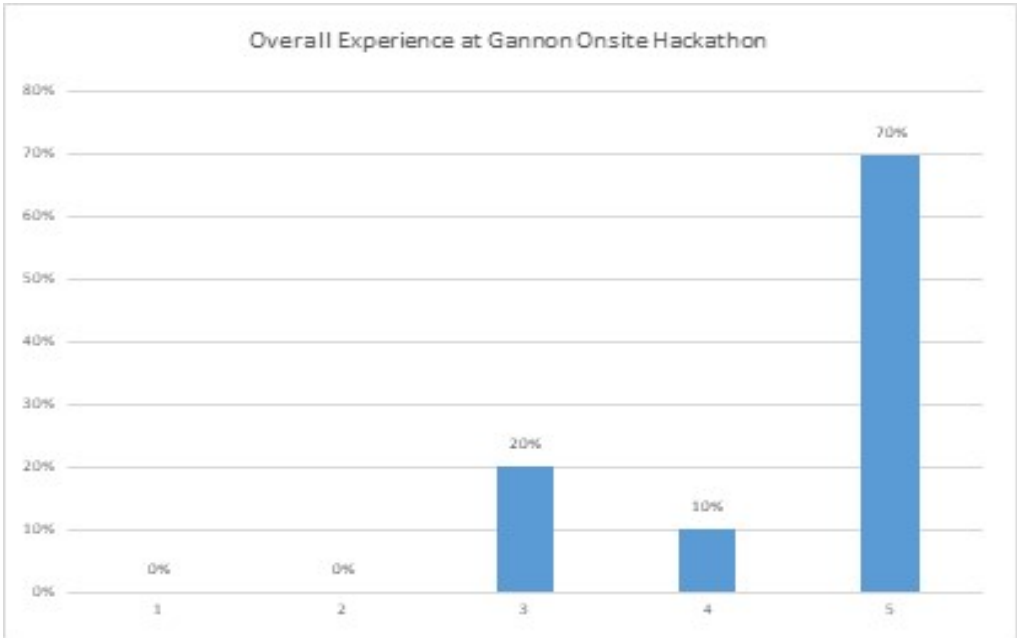


Figure 6. Overall Experience at Gannon Onsite Hackathon

Students were also surveyed on their overall experience after the on-site hackathon. Experience is rated from 1 to 5 with one being the worst experience and five as the best experience. Seventy percent of students rated Gannon's on-site hackathon as the best experience.

Due to the geographical limits, there were only 53 students who attended Gannon On-site Hackathon in the year 2019 and 2020 combined. The winners of on-site hackathon were awarded with a Gannon University full scholarship. 30 students who attended our Cybersecurity Hackathon enrolled into Gannon University in Fall semester 2019 and 2020. Half of them were from out of state cities such as Cleveland, OH and Buffalo, NY.

## 5. Open Challenges

There were some shortcomings of the project. First, the OWASP Juice Shop has been known for years. Some solutions for challenges can be easily found on the internet. Also, the test bank is not big enough to support an annual event for several years. Thus, a new system with a customizable test bank is a necessity from a long term view. This same problem happened with the on-site hackathon test. While we want every student to learn and practice cybersecurity, currently there is only one scholarship offered from Gannon. The balance of requirements is a challenge to designers of such projects. Currently, we applied the format of a certification exam. However, the content of the certification exam is not perfect to inspire academic interests among high school students. Such a challenge is not only in the cybersecurity area, but for all majors.

## 6. Conclusion

In this paper, we introduced how Gannon University hosted a hackathon event for high school students interested in a cybersecurity major. The event is a combination of both virtual and on-site activities.

Gannon University is a small teaching school in a relatively small, populated city (under 100,000). Student enrollment is key for the University and surrounding businesses. At the same time, the University is not able to invest a large amount of funding to boost one or two new majors. For all these reasons, the hackathon event was designed with financial efficiency. With the fast pace of business, faculty did not have enough time to develop a new system for University recruitment and marketing. To adopt an open-source software was the only choice with just two months allowed for the project, including collaborating with multiple offices from different disciplines. What we hope to demonstrate here is not only an education or technical project, but also a comprehensive project at an institutional level. We hope our experience can help other schools like Gannon University.

During the development we tried our best to customize the project with Gannon's unique culture and environment. A general e-commerce website was modified into the University gift shop. This fits with the marketing and recruitment purpose of the whole project, right down to considerations of the various backgrounds of our high school students. The "hacking" environment was fun and safe. Students had an opportunity to face a "real" attacking target. The feedback demonstrated that our goal and expectations were achieved.

## Acknowledgement

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