Entrepreneurial-Minded Learning in a Freshman Mini-project in Computing

Dr. Danai Chasaki, Villanova University

Danai Chasaki received a Diploma in Electrical and Computer Engineering from the National Technical University of Athens, Greece in 2006. She also received a M.S. and a Ph.D. degree in Electrical and Computer Engineering from the University of Massachusetts Amherst in 2009 and 2012 respectively. In 2012, she joined the Department of Electrical and Computer Engineering at Villanova University as an Assistant Professor. Before that, she was an Adjunct Instructor at Worcester Polytechnic Institute and a Research Assistant at the Network Systems Lab of the University of Massachusetts Amherst. Danai’s current research interests include embedded system design, network security and cyber-physical systems. She is a member of the IEEE, the ACM and the ASEE. She is active as program committee member of some professional conferences including IEEE ICNP and ACM/IEEE ANCS.
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Computing and Information Technology are among the fastest growing fields in the U.S. and participating in efforts to attract and retain students in this major is critical. The Computing field offers a unique opportunity for exciting industry-sponsored mini-projects that involve hands-on experience and link the applicability of computing skills to the industry world. Technical understanding is essential to engineering. But engineers find success and personal fulfillment when they couple these skills with a mindset to create extraordinary value for others. Our mini-project aims at providing an immersive experiential learning experience that introduces students to engineering entrepreneurial-minded principles[1] (EML).

In this paper, we discuss the design of a seven week long lab offered in the beginning of the freshman year, where students get real world experience on cyber-security, computer networks, and the economics behind security attacks and security solutions. The theme of the mini-project is CSI; students form two groups, the “hackers” and the “defenders” and for the first six weeks of the project they rotate roles while trying to solve various tasks[2]. The teams learn the basics of password cracking, password strength, wireless security, network monitoring, biometrics etc. The seventh week of the mini-project is reserved for the entrepreneurial-minded learning (EML) activity.

By the end of the seven-week period students are able to identify popular attacks and discuss potential defense techniques to counter those attacks. They are also able to understand the economics behind security attacks and security solutions, and think about contributions they could make to the security community/industry. Another important objective of the mini-project is for students to be able to effectively function as a team member, with effectiveness being determined by peer rating and self-assessment (using CATME.org questionnaires[3]). We use a concept inventory in the beginning of the course in order to determine students’ interest and involvement in entrepreneurial-minded learning. This inventory is also used as pre-test data in our end of the course inventory, where we reassess students’ interest and confidence in entrepreneurship to measure the effectiveness of the instruction.

I. Introduction

The College of Engineering at Villanova University has established a new seven-week course that is required for freshman-engineering students. An integral part of this new course is an interdisciplinary project-based experience, which according to the literature, has shown to be an effective way to improve learning in freshman as well as upper level courses[4-10]. Previous work in project-based, hands-on learning experiences shows that restructuring of the freshman
year can allow for education of the freshman students so that engineering analytical tools can quantify what is already understood in a qualitative sense.

Since the course is by nature multi-disciplinary, we found it to be well suited for an educational experience on entrepreneurial minded learning. An entrepreneurial mindset consists of three key elements: Curiosity, Connections, and Creating Value. Entrepreneurially minded individuals:

- have a constant curiosity about our changing world and employ a contrarian view of accepted solutions;
- habitually connect information from many sources to gain insight and manage risk; and
- create value for others from unexpected opportunities as well as persist through, and learn from, failure.

Villanova University belongs to the Kern Entrepreneurial Engineering Network[1] (KEEN), a collaborative partnership of colleges and universities dedicated to graduating engineers with an entrepreneurial mindset so they can create personal, economic, and societal value through a lifetime of meaningful work. After recognizing the importance of the entrepreneurial mindset, we strive to integrate it in our freshman engineering class reaching all 250 of our entering freshmen.

II. Project Theme

The theme of the mini-project is Cyber Crime Scene Investigation; we recreate a modern crime scene scenario – a technology savvy criminal breaks into a corporate organization’s premises, cracks passwords, obtains access to sensitive information, but luckily leaves traces behind - and have students form teams with rotating roles. Some teams assume the “hacking” role and the rest are on the “defensive” side.

We break down our cyber crime scene case into several modules, and develop weekly lab exercises. Teams learn how to work together to solve the task at hand. Such tasks include but are not limited to: trying different combinations to unlock a pin-based lock, cracking a computer login password[11], detecting fingerprints the hacker left on the keyboard[12], decrypting a secure file that contains sensitive information, cracking network/email passwords, etc. Through these tasks, we teach students fundamentals of computer engineering and networking as well as key mathematical aspects and chemistry aspects that tie well with cyber-security.

A nice complement to the technical skills the students acquire through these security modules is to get the students thinking about how to make a world-changing impact using their skills. The minds of freshmen are particularly receptive to creative and ambitious ideas, and we found that freshman year is a great time to introduce Entrepreneurial-minded learning concepts. Throughout this mini-project we reinforce our moto that “It’s not just about a skill. It’s about a
mindset”. Technical understanding is essential to engineering. But engineers find success and personal fulfillment when they couple these skills with a mindset to create extraordinary value for others. The key is an entrepreneurial mindset. And it can be applied to any subject, including engineering.

III. Modular Approach

We design the EML activity using several active learning modules. First, as shown in Figure 1., we refer to several headlines from the news related to cyber security attacks, and the financial threat they pose to corporations, as well as the US infrastructure (for example the Stuxnet worm, the SONY PlayStation breach etc.).

![News Headlines](image)

Figure 1. News Headlines

Then we ask students to brainstorm teams – inspired by the headlines – about the biggest security issue they can think of, and how they can help defend against it using the technical skills they acquired in the first six weeks of the project. By the end of this module, we expect each team to narrow their security solutions down to the best two. The next step is for the team to give a 2-min pitch to the instructors and the TAs for both ideas. The concept is similar to the popular TV show “Shark Tank”; in our module the instructors judge the students pitch and select the best idea of every team to be presented as a poster presentation.

In the beginning of the mini-project, we introduce the objectives of the EML exercise, and set clear expectations for the deliverables, so that the students can start thinking about their security solutions as they learn the material during the first six weeks. We also teach the fundamentals of business concepts, like value proposition, customer segments, and introduce the concept of a modified business canvas[^13], which is a helpful tool for every new business in order to make their product idea perfectly aligned with their customers needs.
Every “start-up” team completes only the Value Proposition and Customer Segments sections of the canvas shown in Figure 2., to make sure they understand what value their business idea brings to the table, and how it fits the customer’s needs.

![Figure 2. Business Model Canvas](image)

IV. Assessment

In the beginning of the course, we use a survey in order to determine students’ interest and involvement in entrepreneurial-minded learning. This survey is also used as pre-test data in our end of the course survey, where we reassess students’ interest and confidence in entrepreneurship to measure the effectiveness of the instruction.

Sample survey questions measure to what students feel that they:

1. Exercise curiosity about the surrounding world
2. Define problems, opportunities, and solutions in terms of value creation
3. Are capable of assessing risk of success/failure of a new venture
4. Persist through and learn from failure
5. Demonstrate resourcefulness

We also quantify how effectively students think they accomplish the following:

6. Collaborate in a team setting
7. Understand the motivations and perspectives of stakeholders (customers etc.)
8. Communicate engineering solutions in economic terms
9. Substantiate claims with data and facts
10. Persuade others with facts

Figures 3 and 4 present our findings. Out of 54 subjects we saw that by the end of the EML activity most students felt more confident about their answers to the ten questions, and less students checked the “not applicable” box.

![Figure 3: Students’ responses to ten questions before EML activity](image1)
(The Y-axis indicates the number of students who responded Yes/no/not applicable, and the X-axis Questions 1 through 10)

![Figure 4: Students’ responses to ten questions after EML activity](image2)
(The Y-axis indicates the number of students who responded Yes/no/not applicable, and the X-axis Questions 1 through 10)
Looking at the ten questions as an aggregate, the average “YES” responses increased by 15%, whereas the average “NO” responses decreased by 44% and the “not applicable” responses decreased by 72%.

In terms of the overall mini-project assessment, at the end of each week we require individual and team progress reports demonstrating the week’s effort on the specific task and discussing challenges. As summative assessment, we administer several quizzes and assess students’ presentation skills by requiring a group poster presentation in the end of the semester. Students form groups of three, and choose to work on one of the weekly assignments. They discuss the challenges they face while solving the problem and the key take-away points of the assignment. One of the most successful posters is shown in Figure 5.

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**Print Pay**

- **Pros**
  - More secure, as fingerprint is unique to each individual
  - Would result in less fraud, helping insurance companies and credit card companies alike
  - No physical object to use that can easily be stolen, forgotten, or misplaced

- **Cons**
  - Would require implementation of print scanners in stores
  - The registering of the fingerprint would take time and resources for customers and companies alike

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**Print Pay**

- Could the modern plastic credit card be extinct?
- Print Pay is a more secure form of payment than, instead of using a number on a card, uses a person’s fingerprint
- Utilizing fingerprint scanning technology, one would simply apply their thumb to a scanner instead of presenting a credit card
- It would not put credit card companies out of business by any means, but rather expand the technology of transactions

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**Looking to the Future...**

- A Norway based company, Zwipe, has been working with Mastercard to test out biometric scanning payment technology
- The companies have done preliminary testing in the US and Norway and have expanded to Canada
- Companies such as Visa and American Express are following suit and working on biometric technology of their own

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Figure 5. Sample student poster presentation
V. Acknowledgements

Special thanks to Dr. Richard Perry, who co-developed and co-taught this project-based course.

VI. References