

A "DIVERGENT"-THEMED CTF AND URBAN RACE FOR INTRODUCING SECURITY AND CRYPTOGRAPHY

Motivation

Opportunity for learning by practice
This activity is designed to be a fun and engaging way to introduce students to the concepts of security and cryptography. It is a hands-on activity that allows students to apply their knowledge of these concepts in a practical setting.

Curriculum

Version
1.0

Author
[Name]

License
[License]

Why it's useful
[Text]

CTF

Format
[Text]

Number
[Text]

Image
[Image]

Storyline

Act 1
[Text]

Act 2
[Text]

Act 3
[Text]

CTF segment
[Text]

Conclusion
[Text]

Security Jeopardy!

Security jeopardy game
[Text]

Rules
[Text]

Image
[Image]

Urban race

Urban race
[Text]

Image
[Image]

Why?

Why
[Text]

Image
[Image]

Using the material

How to use
[Text]

Image
[Image]

Image
[Image]

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Curriculum

Version:
1.0

Author:
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License:
[License]

Keywords:
[Keywords]

CTF

Format:
[Format]

Duration:
[Duration]

Difficulty:
[Difficulty]

Storyline

Plot:
[Plot]

Characters:
[Characters]

Setting:
[Setting]

Security Jeopardy!

Format:
[Format]

Duration:
[Duration]

Difficulty:
[Difficulty]

Urban race

Format:
[Format]

Duration:
[Duration]

Difficulty:
[Difficulty]

Why?

Why?
[Why?]

Using the material

How to use:
[How to use]

Resources:
[Resources]

Motivation

Expanding the security pipeline

Introduce students to computer security early

Camps and classes

- CyberDiscovery, CyberPatriot, CyberAcademy, GenCyber

Capture-the-Flag (CTF) security games

- picoCTF, hs-CTF, abctf

This work

Combined camp and CTF for introducing security topics in an engaging way

Focus on intrinsic motivation

- Scaffolded CTF game to cultivate confidence and competence
- Urban Race to augment learning with physical activity
- Embedded fictional storyline to blend real and virtual world

Goal: Create a positive first experience with computer security

Expanding the security pipeline

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Curriculum

Version:
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Author:
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Keywords:
[Keywords]

CTF

Format:
[Format]

Number of teams:
[Number]

Duration:
[Duration]

Storyline

Plot:
[Plot]

CTF objectives:
[Objectives]

Challenges:
[Challenges]

Security Jeopardy!

Security jeopardy game:
[Game description]

Rules:
[Rules]

Prizes:
[Prizes]

Urban race

Urban race:
[Race description]

Challenges:
[Challenges]

Prizes:
[Prizes]

Why?

Why?
[Reasons]

Using the material

How to use:
[Instructions]

Additional resources:
[Resources]

Curriculum

Overview

Curriculum goals

- Data encoding and cryptography
- Security concepts and tools

Structure

- 5 modules and a movie ("The Imitation Game")
- No prior experience assumed

Modules

Module #1: Motivation

- Importance of cryptography and security in history

Module #2: Data encoding

- Information in the digital age
- Binary, hexadecimal, ASCII, barcodes, QR codes, steganography



Module #3: Simple ciphers

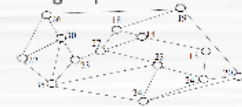
- Transposition ciphers
 - Columnar transposition, Scytale
- Substitution ciphers
 - Monoalphabetic substitution (Caesar, simple)
 - Polyalphabetic substitution (Vigenere, Enigma)

```
GERMAN AEGNMR  
deFend nededf  
ilness ahfscz  
lwl.llo lwt.lom  
fhucso ct'fesh  
vslr.. .fsh.l
```



Module #4: Modern ciphers

- Public-key cryptography
- Dominating set problem



Module #5: Cryptographic protocols

- Man-in-the-Middle attacks

Lecture format

Alternating lecture and collaborative practice

- Each team given a puzzle made up of sub-puzzles
- Individual members solve a sub-puzzle
- Solutions combined

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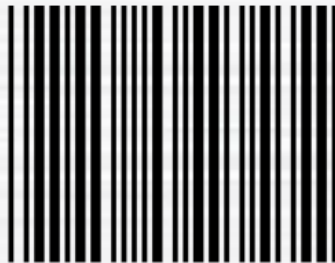
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Module #2: Data encoding

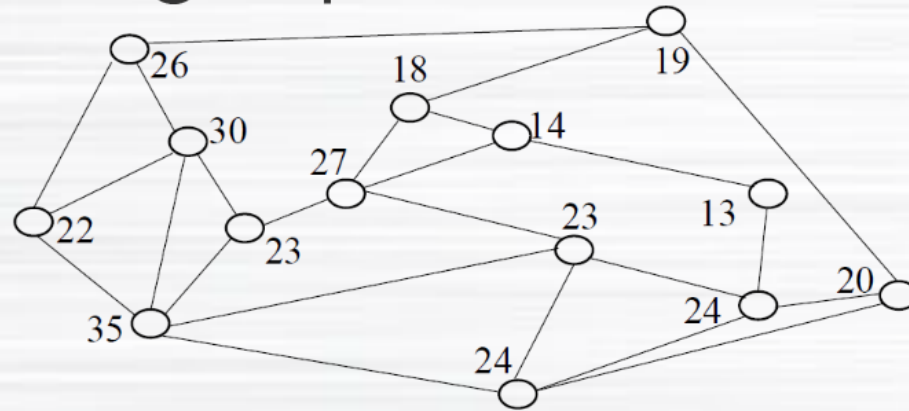
- Information in the digital age
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Binary	Hex	Decimal
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7
1000	8	8
1001	9	9
1010	A	10
1011	B	11
1100	C	12
1101	D	13
1110	E	14
1111	F	15



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Module #5: Cryptographic protocols

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Try to work
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Curriculum

Version
1.0.0
This version of the curriculum was created in 2023 and is the most up-to-date version available.

Authors
The curriculum was developed by a team of experts in the field of security and cryptography, including [names redacted].

Why we did it
The goal of this curriculum is to provide students with a comprehensive understanding of security and cryptography, and to equip them with the skills and knowledge necessary to protect themselves and their organizations from cyber threats.

CTF

Format
The CTF is a team-based competition where students are given a series of challenges to solve. The challenges are designed to be both fun and educational, and are intended to test students' knowledge and skills in a variety of areas, including cryptography, network security, and reverse engineering.

Storyline

Plot
The storyline of the CTF is set in a futuristic world where a powerful organization has developed a new technology that could revolutionize the way we live and work. However, this technology is being used for nefarious purposes, and it is up to the students to uncover the truth and stop the organization before it's too late.

Why?

For
The CTF is designed to be a fun and engaging way to introduce students to the concepts of security and cryptography. It is a hands-on activity that allows students to apply their knowledge and skills in a practical setting.

Using the material

For the
The material is designed to be used in a variety of ways, including as a standalone activity, as part of a larger course, or as a resource for teachers and students alike.

CTF

Format

24 scaffolded challenges

- Given in sets during the week based on daily module
- Designed to cultivate confidence and competence
- Simple, common gameplay mechanism
 - Decode message to find the key that unlocks a file
 - Focus on technical skills being developed

Example

```
116 104 101 32 107 101 121 32 102 111 114
32 116 104 101 32 115 101 118 101 110 116
104 32 105 115
```

```
t h e k e y f o r
t h e s e v e n t
h i s
```

Example

🌀❖🌀 ●🌀🌀 🌀🌀🌀 🌀🌀🌀

🌀❖🌀🌀🌀🌀🌀🌀🌀 🌀🌀

the key for june

thirteenth is



Format

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Why we did it
The goal of this curriculum is to provide a comprehensive and engaging introduction to the concepts of security and cryptography for students. It is designed to be a fun and interactive learning experience that allows students to apply their knowledge in a practical setting.

CTF

Format
The CTF is a team-based competition where students are given a series of challenges to solve. The challenges are designed to be fun and engaging, and they cover a wide range of topics related to security and cryptography.

Rules
The rules of the CTF are simple and straightforward. Teams are given a set amount of time to solve the challenges, and the team that solves the most challenges in the least amount of time wins.

Prizes
The winning team will receive a trophy and a certificate of achievement. There will also be prizes for the runner-up and the team that solves the most challenges.

Storyline

Plot
The storyline of the CTF is a mystery that unfolds as students solve the challenges. The plot is designed to be fun and engaging, and it provides a context for the challenges.

Characters
The characters in the storyline are a group of students who are competing in the CTF. They are each given a role to play, and they work together to solve the challenges.

CTF objectives
The objectives of the CTF are to provide a fun and engaging learning experience for students, to introduce them to the concepts of security and cryptography, and to provide them with a chance to apply their knowledge in a practical setting.

Security Jeopardy!

Security jeopardy game
The Security Jeopardy! game is a fun and engaging way to test students' knowledge of security and cryptography. It is a game show-style activity where students are asked to answer questions about these topics.

Rules
The rules of the Security Jeopardy! game are simple and straightforward. Students are given a set amount of time to answer the questions, and the student who answers the most questions correctly wins.

Prizes
The winning student will receive a trophy and a certificate of achievement. There will also be prizes for the runner-up and the student who answers the most questions correctly.

Urban race

Urban race
The Urban Race is a fun and engaging way to introduce students to the concepts of security and cryptography. It is a hands-on activity where students are given a series of challenges to solve in a real-world setting.

Rules
The rules of the Urban Race are simple and straightforward. Students are given a set amount of time to solve the challenges, and the team that solves the most challenges in the least amount of time wins.

Prizes
The winning team will receive a trophy and a certificate of achievement. There will also be prizes for the runner-up and the team that solves the most challenges.

Why?

Why?
The reason for creating this curriculum is to provide a comprehensive and engaging introduction to the concepts of security and cryptography for students. It is designed to be a fun and interactive learning experience that allows students to apply their knowledge in a practical setting.

Using the material

How to use
The material can be used in a variety of ways, including as a classroom activity, a team-building exercise, or a fun and engaging way to introduce students to the concepts of security and cryptography.

Specific instructions
The specific instructions for using the material are provided in the accompanying document. They include information about the format of the CTF, the rules of the Security Jeopardy! game, and the rules of the Urban Race.

Storyline

Idea

Embed CTF challenges into a familiar, contemporary story

- Provide extra level of engagement
- Challenges open up individual parts of story
- "Divergent" series by Veronica Roth

Why Divergent?

Familiar to this generation

- Books > 30 million copies

Relevant plot to overall CyberPDX GenCyber camp

- Use and abuse of technology
- Diversity theme
 - Female protagonist
 - Importance of people with diverse skills and expertise
- Computer security subplot amenable to adaptaion

Plot

Story of 5 clans

- Dauntless, Abnegation, Erudite, Candor, Amity

"The Traitor" short story

- Divergent as told through the eyes of Four
- Four suspects plan to eliminate Abnegation
- Works to break into computer systems of Dauntless and Erudite leaders to thwart plan
- Uses shoulder surfing, backdoors, trojans, and rootkits



CTF adaptation

Four has disappeared just before camp

Tris contacts campers for help

- Clues include a USB key with an electronic diary on it and some printouts of encoded messages
- Printouts encode keys to unlock diary entries
 - From Four's control room security training
 - Training that is now being given to students
- Tris asks campers to find out what Four was working on

Challenges

Encoded messages are CTF challenges

- Printouts containing scaffolded levels
- Must decode each to reveal key
- Key unlocks an individual diary entry
- Difficulty steadily increases

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Curriculum

Version
1.0

Authors
[List of authors]

Subjects
[List of subjects]

Keywords
[List of keywords]

CTF

Format
[Details of CTF format]

Duration
[Duration of CTF]

Storyline

Plot
[Summary of the storyline]

CTF objectives
[List of CTF objectives]

Security Jeopardy!

Security jeopardy game
[Details of the jeopardy game]

Rules
[List of rules]

Urban race

Urban race
[Details of the urban race]

Rules
[List of rules]

Why?

Why?
[Reasons for the activity]

Using the material

How to use
[Instructions on how to use the material]

License
[License information]

Security Jeopardy!

Revisiting curricular goals

- Introduce cryptography
 - Done via CTF challenges
- Introduce security concepts and tools
 - Attempt to inspire curiosity and appreciation for computer security
 - Best done in context in a memorable way
 - Use engagement in story and plot device of the diary
 - Four's first-person account of penetration testing

Mechanics

- Diary set in preceding month
- Each entry describes a method Four employs
- Tools and techniques central to computer security Jeopardy! mechanic
 - Actual tool or technique not disclosed directly
 - Puzzle within a puzzle
 - Students research an aspect of computer security to identify Four's method

Example entry

June 23

Before getting caught on Mark's computer, I managed to get a packet trace showing Mark's network connections to, among other things, Google servers. Since the Google bots have already checked every existing connection to their systems, it will be tough to find out which service are available. Manually checking each potential network address and port would take too long, but I've learned that there are many automated tools that can help. One such tool is called nmap. It is a network scanner that will automatically probe a network to see what servers and services are open. While that will be a very helpful, what I really need is something to tell me what is open "not" vulnerable. For that, there is another tool that people in the past used. The scanner I found that does this was released in 1995 and is quite terrible (see intended).

UNSESS

Story

Follow Four and figure out how he....

• How can I see if my system is vulnerable?
• How do I know if my system is vulnerable?
• How do I know if my system is vulnerable?
• How do I know if my system is vulnerable?
• How do I know if my system is vulnerable?

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Mechanics

Diary set in preceding month

Each entry describes a method Four employs

Tools and techniques central to computer security

Jeopardy! mechanic

- Actual tool or technique not disclosed directly
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Example entry

June 25

Before getting caught on Max's computer, I managed to get a packet trace revealing Max's network connections to, among other things, Erudite servers. Since the Erudite have likely blocked many incoming connections to their systems, it will be helpful to find out which services are available. Manually checking each potential network address and port would take me forever, but I've learned that there are many automated tools that can help. One such tool is called nmap. It is a network scanner that will automatically probe a network to see what servers and services are open. While that will be clearly helpful, what I really need is something to tell me what is open *and* vulnerable. For that, there is another tool that people in the past used. The scanner I found that does this was released in 1998 and is quite tenable (pun intended):

U N S E S S

Story

Follow Four and figure out how he....

- Uses a surveillance camera to obtain Max's password
- Installs a backdoor to maintain access to Max's computer
- Discovers an intrusion detection system protecting the computer
- Exfiltrates data covertly from the system
- Covers his activity to avoid detection
- Breaks the encryption employed on Max's files
- Attempts to monitor all network traffic
- Is caught via the use of a fake program
- Attempts to subvert Max's hardened replacement computer
- Employs a social engineering attack that fails as a result of a password manager
- Attempts a session hijacking attack that fails due to script blocking and encryption
- Performs anonymous reconnaissance on Erudite systems
- Exploits vulnerabilities to move laterally within the Erudite network
- Uncovers an air-gapped system at the heart of the Erudite plan

- Uses a surveillance camera to obtain *Max's* password
- Installs a backdoor to maintain access to *Max's* computer
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Keywords
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Dependencies
[Dependencies]

CTF

Level
[Level]

Number
[Number]

Order
[Order]

Storyline

Act 1
[Storyline]

Act 2
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Act 3
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CTF objective
[CTF objective]

Goal
[Goal]

Security Jeopardy!

Security jeopardy game
[Security jeopardy game]

Rules
[Rules]

Questions
[Questions]

Answers
[Answers]

Urban race

Urban race
[Urban race]

Rules
[Rules]

Questions
[Questions]

Answers
[Answers]

Why?

Why?
[Why?]

Why?
[Why?]

Why?
[Why?]

Using the material

How to use
[How to use]

How to use
[How to use]

How to use
[How to use]

Urban race

Live story

Capstone activity

- CTF storyline leads to climax in the present
- Pivot from scheduled lecture to live action
- Students inserted into plot directly
- ~2 hour Urban Race finale

Story setup

Tris relays urgent message from Four

- Trapped outside of Erudite control room
- Protected by puzzles to ensure only Erudite get in
 - Requires advanced cryptography skills
 - Knowledge of the Erudite (PSU) campus
- Must be solved quickly with under 10 incorrect attempts
- Gives each team Four's Twitter handle

Race

Modeled after CitySolve, ChallengeNation, Amazing Race

- Tris relays a set of cryptographic clues given to Four
- Once decrypted, clues send teams throughout campus
- Communication with "virtual" Four to relay answers



Four-bot

Four as a Twitter bot

- Gives illusion of interacting with the actual character
- Takes answers and updates storyline state
- Each team given independent story instance
- Allows each team to "save the city"
- First place team quietly given extra challenge
 - Leads to a lock box and special prize



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ivaharici macvii @1118408111 · 20 JUN 2019

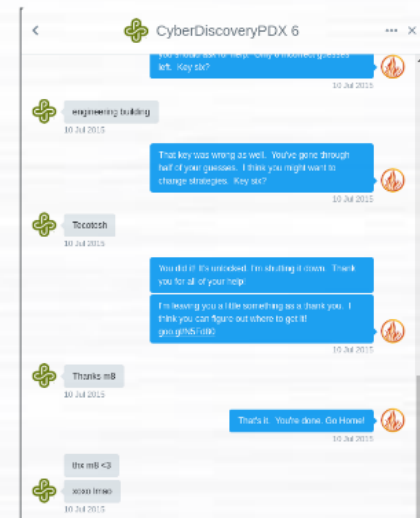
Feverishly working on the last crypto challenge! Time matters to get info to @CDFour!



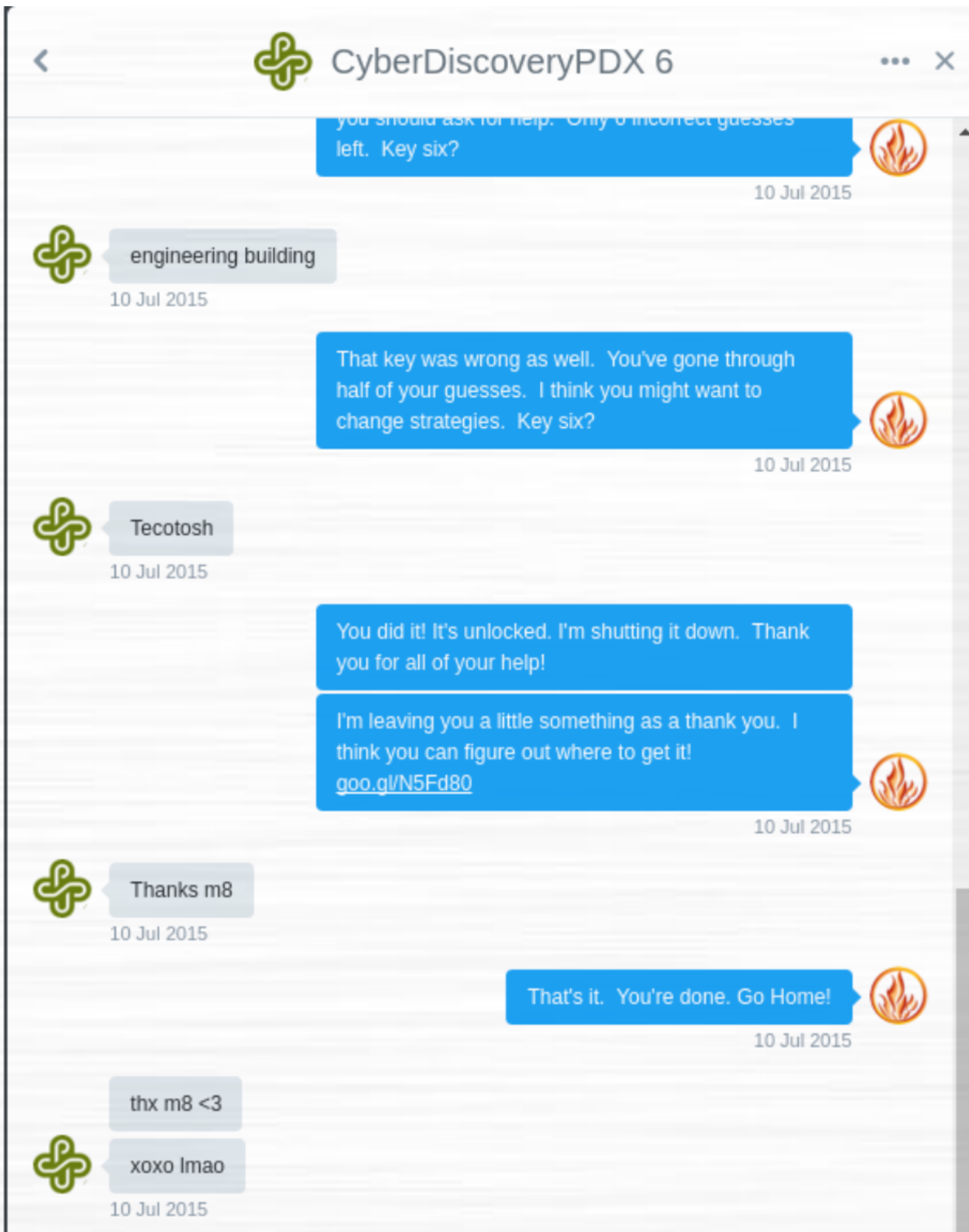
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Storyline

Act 1
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Act 2
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Act 3
[Storyline]

CTF segment
[CTF segment]

Conclusion
[Conclusion]

Security Jeopardy!

Security jeopardy game
[Security jeopardy game]

Rules
[Rules]

Questions
[Questions]

Answers
[Answers]

Urban race

Urban race
[Urban race]

Rules
[Rules]

Questions
[Questions]

Answers
[Answers]

Why?

Why?
[Why?]

Why?
[Why?]

Why?
[Why?]

Using the material

How to use
[How to use]

How to use
[How to use]

How to use
[How to use]

How to use
[How to use]

Why?

Flow

Coined in 1990 by Mihaly Csikszentmihalyi

- Single-minded focus on a task that aligns a person's emotions and motivation with objective at hand
- Characterized by deep enjoyment, creativity, and a total involvement with life.
- Powerful intrinsic motivator

Key in making engaging learning experiences

- Often brought out in CTF events and games

Mihaly Csikszentmihalyi, "Flow: The Psychology of Optimal Experience", 1990.

Designing for Flow

Employ known triggers for flow

- Within CTF
 - Clear goals
 - Balance of challenge and skill level
 - Immediate feedback
 - Rich environment
- Additionally in urban race
 - Risk
 - Common, shared goal
 - Constant group communication

Steven Kotler, "The Rise of Superman", 2014

Success?

2016 CyberPDX Urban Race Winners



An elusive unicorn...

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A "DIVERGENT"-THEMED CTF AND URBAN RACE FOR INTRODUCING SECURITY AND CRYPTOGRAPHY

Motivation

Opportunity for learning by practice
This activity is designed to be a fun and engaging way to introduce students to the concepts of security and cryptography. It is a hands-on activity that allows students to apply their knowledge of these concepts in a practical setting.

Try to work
This activity is designed to be a fun and engaging way to introduce students to the concepts of security and cryptography. It is a hands-on activity that allows students to apply their knowledge of these concepts in a practical setting.

Curriculum

Version
1.0.0

Author
[Name]

License
[License]

Keywords
[Keywords]

Dependencies
[Dependencies]

CTF

Level
[Level]

Number
[Number]

Order
[Order]

Storyline

Act 1
[Storyline]

Act 2
[Storyline]

Act 3
[Storyline]

CTF objective
[CTF objective]

Goal
[Goal]

Security Jeopardy!

Security jeopardy game
[Security jeopardy game]

Rules
[Rules]

Questions
[Questions]

Answers
[Answers]

Urban race

Urban race
[Urban race]

Rules
[Rules]

Questions
[Questions]

Answers
[Answers]

Why?

Why?
[Why?]

Why?
[Why?]

Why?
[Why?]

Using the material

How to use
[How to use]

How to use
[How to use]

How to use
[How to use]

Using the material

Offerings

CyberDiscovery Portland State (7/2015)
Portland State New Beginnings (9/2015, 7/2016)
Lewis and Clark College (1/2016)
Lincoln High School (4/2016)
CyberPDX (7/2016)



For teachers

All course material available at:

- <https://cyberd.oregonctf.org>

For access to source code to customize CTF or Urban Race

- Contact wuchang@pdx.edu

Play the game

- Copies of CTF challenges
- Demo mini-urban race with prizes after session

CyberPDX student evaluation

54 10th grade students (32 female, 23 male)
1=strongly disagree
5=strongly agree

I am more comfortable learning about cybersecurity.	4.24
I learned a lot about cybersecurity	4.53
I enjoyed learning about cybersecurity	4.30
I enjoyed the projects and activities at this camp	4.40
I would like to learn more about cybersecurity	4.02

Specific feedback

Students

- I liked the crypto challenges a lot because it was really satisfying to figure out the hidden codes.
- Solving the crypto challenges. I thought that it was extremely well put together and was equally challenging and fun...The problem-solving and creativity part of this thread is something that everyone on our team enjoyed and appreciated.
- The cryptography was a lot of fun to crack and solve.

Teachers

- Love the puzzle within a puzzle hook and motivator... Students definitely got into this.
- The interconnectedness built into the progressive challenges was superbly handled, and the scavenger hunt was phenomenal!
- Well planned and implemented. My students were able to apply their knowledge and have fun.

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Curriculum

Version:
1.0

Author:
[Name]

License:
[License]

Keywords:
[Keywords]

Subjects:
[Subjects]

CTF

Format:
[Format]

Number of teams:
[Number]

Duration:
[Duration]

Storyline

Plot:
[Plot]

Characters:
[Characters]

CTF objectives:
[Objectives]

Challenges:
[Challenges]

Security Jeopardy!

Security jeopardy game:
[Game description]

Rules:
[Rules]

Prizes:
[Prizes]

Urban race

Urban race:
[Race description]

Challenges:
[Challenges]

Prizes:
[Prizes]

Why?

Why?
[Reasons]

Using the material

How to use:
[Instructions]

Resources:
[Resources]

Lecture format

Alternating lecture and collaborative practice

- Each team given a puzzle made up of sub-puzzles
- Individual members solve a sub-puzzle
- Solutions combined
- Enables horizontal learning

- Example

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