

**Abstract**

Cyber security has increasingly become important due to the escalating frequency and sophistication of on-line attacks, as well as the consequences of these attacks for various organizations and their infrastructures. This is an emerging field which requires real life experience to solve on going security challenges. Demand for cyber security professionals is ever increasing, and by 2019 the demand is reported to increase to 6-million, with a projected shortfall of 1.5-million. The goal of this project is to improve the effectiveness of cyber security education through puzzle-based learning (PBL), expanding student knowledge and problem solving skills through the stimulation of their cognitive abilities. PBL has already proven effective in many STEM learning environments including mathematics, physics, and computer science. This research project – developed with “Unreal Engine” (UE4) – introduces novice users to abstract security concepts, enabling critical thinking through the solving of complex puzzles. Therefore, this research project will play a significant role in improving the critical thinking skills for next generation cyber security professionals

**Puzzle**



“A **puzzle** is a problem or enigma that tests the ingenuity of the solver.” – Wikipedia

- **Generality**
- **Eureka Factor**
- **Simplicity**
- **Entertainment Factor**

- ❖ **A new way of learning**
- ❖ **Better productivity than traditional learning** - About 500% (Ref: Michalewicz Z, Michalewicz M, Puzzle Based learning)
- ❖ **Increases critical thinking and participation**

**Puzzle Based Learning**

❖ **Steps**

- ❖ Introduction to the topics through lectures
- ❖ Interactive Story with problems
- ❖ Story can be led different directions in accordance to feedback to the problems

❖ **Learning**

- ❖ Participants interact with the story and also the problem
- ❖ Participants use logical reasoning and knowledge obtained from classes
- ❖ Participants become aware of the consequences of their responses as the responses leads the story ahead

**Why Puzzles?**

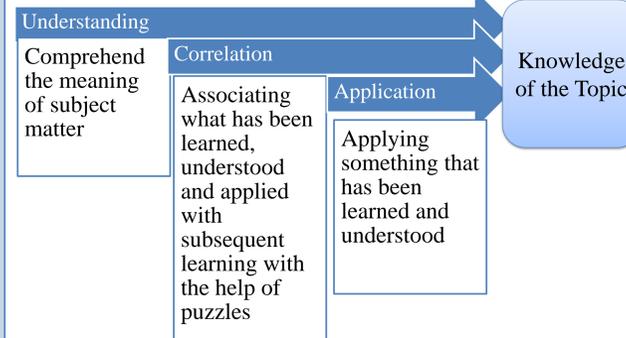
**Puzzle Based Learning**

- Critical Thinking
- Logical & Abstract Reasoning
- Domain Independent

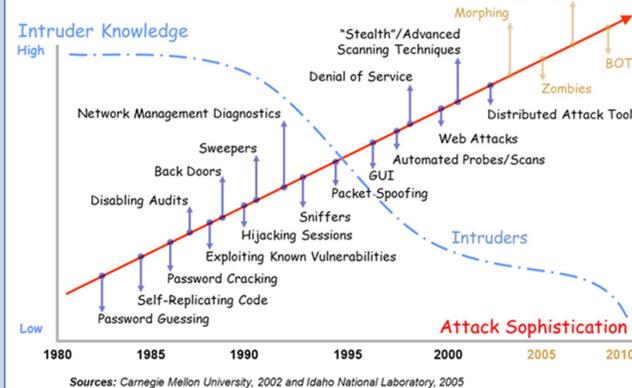
**Project or Problem Based Learning**

- Identifying the Question
- Dealing with Uncertainty
- Reasoning with Domain-specific Methods

**Learning Process**



**ATTACK SOPHISTICATION VS. INTRUDER TECHNICAL KNOWLEDGE**



**Implementation**

❖ **Unreal Engine**

- ❖ Participants solve puzzles in a 3D gaming environment.
- ❖ Allows the participants to interactively engage with the puzzle.
- ❖ Score successful completion of different levels of the 3D game.

**Unreal Engine**

**PIN-PAD Puzzle**

- ❖ The user figures out the PIN using discrete mathematics in order to advance to the next level.
- ❖ There are a number of different permutations depending on the total number of smudges.
- ❖ The user brute forces the correct PIN by entering the different permutations from the previous step.



**Encryption and Decryption Puzzle (Caesar Cipher)**

- ❖ Encryption and decryption of random strings with given hints.
- ❖ The user rotates each wheel to the correct character (clockwise or counter clockwise).
- ❖ Upon selecting all the correct characters the user submits their solution by pressing enter, green lights (win) and red lights (try harder).



**Unreal Engine**

**Result Score**

- ❖ User score displayed after completing each level.
- ❖ Scores are calculated by number of tries and total time spent on each level.
- ❖ The scores will be saved in an encrypted file for the course administrator to grade the participants.
- ❖ The scoring mechanism can be updated according to instructor’s choice.



**Potential Applications**

- ❖ Simulation of Multi-factor authentication. Starting with passwords, security questions, biometrics and then integrate different combinations of them.
- ❖ Simulation of Phishing attacks, how it’s done and how to discern Phishing attempts from legitimate communication.
- ❖ Puzzle based game to introduce different system vulnerabilities, attack vectors, and ways to mitigate possible exploitation of vulnerabilities.

**Conclusion & Future Works**

- ❖ Provokes the **thinking process** by providing challenges.
- ❖ **Interactive process** to engage participants in the story or the problem.
- ❖ Participants will able to see the **future consequences** of their **actions**, makes the learning process interesting.
- ❖ More enlarged versions with other development platforms are being developed as part of NSF grant.
- ❖ User study with two different controlled groups (one with traditional learning, other with Puzzle based learning) are going to be conducted in this semester.

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