NSA Cyber Curriculum Development Initiative: Adversarial Thinking Module

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Discipline Distinctives

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- Math → Logical Thinking
- CompSci → Algorithmic Thinking
- CyberSec → Adversarial Thinking

Adversarial Thinking

- Adversarial thinking is at the heart of cybersecurity
- Sets the orientation of every aspect of the discipline
- Cybersecurity education **must develop adversarial thinking** in students

The Problem

Adversarial thinking is an elusive concept

- How do you define it?
- “Thinking like a hacker” is not good enough for educators
- We need a better definition in order to develop curriculum materials and assess outcomes

My Research: Part 1

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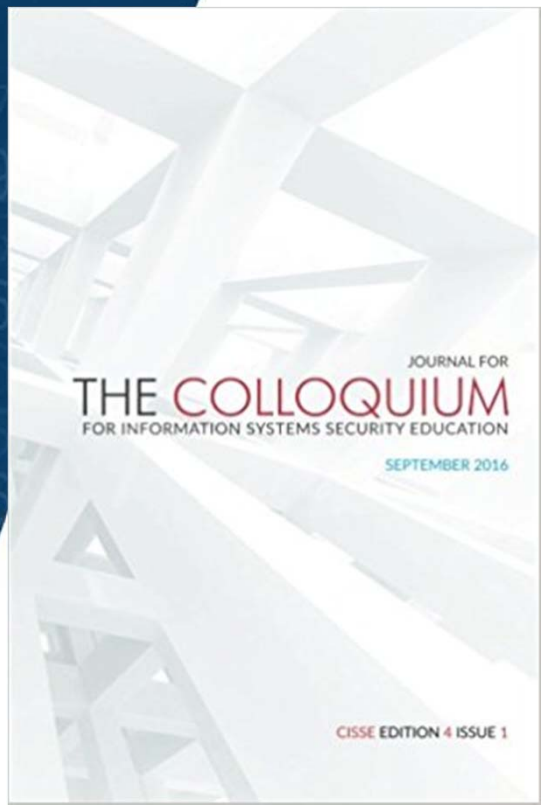
"Teaching Adversarial Thinking for Cybersecurity"

- Defines adversarial thinking
- Based on Sternberg's Triarchic Theory of Intelligence
- Identifies **Strategic Reasoning** as an important component



My Research: Part 2

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"Teaching Game Theory to Improve Adversarial Thinking in Cybersecurity Students"

- Game theory is useful for developing strategic reasoning
- Experiment demonstrated success
- Positive reaction from students

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Student Quotes (1)

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- "[game theory] gives the student a broader idea of how to think when they're analyzing the security of a system. You have to ask yourself, 'How might a hacker look at this?'"
- "…it's a way to try and anticipate others' moves and it's good to try and anticipate what a hacker, what somebody is trying to do to you."
- "I think you need to understand how people react in certain situations…how people are thinking about you…"

"[game theory] gives the student a broader idea of how to think when they're analyzing the security of a system. You have to ask yourself, '**How might a hacker look at this**?'"

Student Quotes (2)

- "I never really thought about that before, how you choose what you are going to do based on what the best outcome is…it was eye opening."
- "…it's interesting and beneficial going through the process of thinking about what the opponent is
- "[game theory] is a fascinating topic…The vast majority of the class has focused on how to carry out [cybersecurity] from a technical perspective. **Balancing that out** with the logic of why and when and where [an attack could] occur is a good [idea]."
- "…cybersecurity that I don't really think about."
- "[game theory] is a fascinating topic…The vast majority of the class has focused on how to carry out [cybersecurity] from a technical perspective. Balancing that out with the logic of why and when and where [an attack could] occur is a good [idea]."

Student Quotes (3)

- "[learning game theory] makes me more aware of being able to think past the simple reaction. I naturally go to level 1 but knowing game theory makes me think there may be a 2nd or 3rd level…"
- "[game theory] helps you react better because you are thinking about what the other person is going to be thinking about and **how he is going to react to your reactions**, rather than just assuming that he is going to be a complete idiot."
- other people are thinking this way."
- "Knowing about game theory helps me understand that [other people] think like me and how my thinking can counteract their thinking."

NSA Curriculum Initiative

- Delivering my game theory module
  - Refining and expanding it
  - Making it easily transferable
- Basic introduction to game theory
- Reinforces adversarial conflict
- Hopefully useful to the community

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TABLE II
GAME THEORY LECTURE TOPICS

Topic	Description
Nagel's Beauty Contest game	In this game the players are asked to guess the number that will be 2/3 of the *average* number guessed by all of the players [19]. Played the game in class with all of the students. The results were tabulated on the spot and then discussed.
Strategic Reasoning	Explained the importance of strategic reasoning for cybersecurity, and how it is an important component of adversarial thinking [1].
Game theory intro	Defined and discussed the history and traditional uses of game theory. Covered the concepts of players, moves, and utility [10].
The Prisoner's Dilemma game and the Nash equilibrium	This game describes a scenario where two suspects are being interrogated separately, and are faced with the dilemma of betraying one another in exchange for a lesser prison sentence versus cooperating with one another by not talking. Explained the methodology used to find the Nash equilibrium, then discussed how doping in sports (e.g., professional cycling) is a real-life prisoner's dilemma game [24].
Real-life game theoretical analysis example	"Solomon's Wise Ruling" (recorded in 1 Kings 3:16-28) is the story of two women who come to King Solomon, each claiming to be the mother of the same baby. To identify the real mother, Solomon rules that the baby shall be cut in two and split between them. Analyzed the scenario using game theory and showed that it predicts the outcome that actually occurred given the women's utility preferences [21].
Behavioral game theory	Defined behavioral game theory and explained the important differences with analytical game theory (see Table I).
Numb3rs clip	Showed a clip from the television show *Numb3rs* that discusses behavioral game theory and the Hide-and-Seek game [25].
The Hide-and-Seek game	In this game the players are asked to guess in which of four boxes (three of which are identical) other players have hidden a treasure. Played the game in class with all of the students. Explained focal point biases and the typical results of the game [22].
The Princess Bride clip	Showed the "Battle of Wits" scene from *The Princess Bride* film to introduce the concept of level-*k* reasoning [23].
Level-*k* reasoning	Discussed the concept of level-*k* reasoning, the definition of L0, and the typical proportions of level-*k* reasoning observed in actual strategic contests by examining the 11-20 Money Request game [27]. Re-examined the in-class Beauty Contest game results.
More game examples	Discussed the Traveler's Dilemma game [20]. Also discussed level-*k* thinking in multiple dimensions with the Colonel Blotto game [26].

Thank You!

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