

A Systematic Mapping Study on Gamification Applications for Undergraduate Cybersecurity Education



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01

Foundation

Introduction &
Background

02

Methodology

Research Questions &
Literature Search

03

Applications

An overview of Cybersecurity
Gamification Applications

04

Discussion

05

Future Work

06

Conclusions

**“If I have seen further, it is by
standing on the shoulders of giants.”**

— Sir Isaac Newton

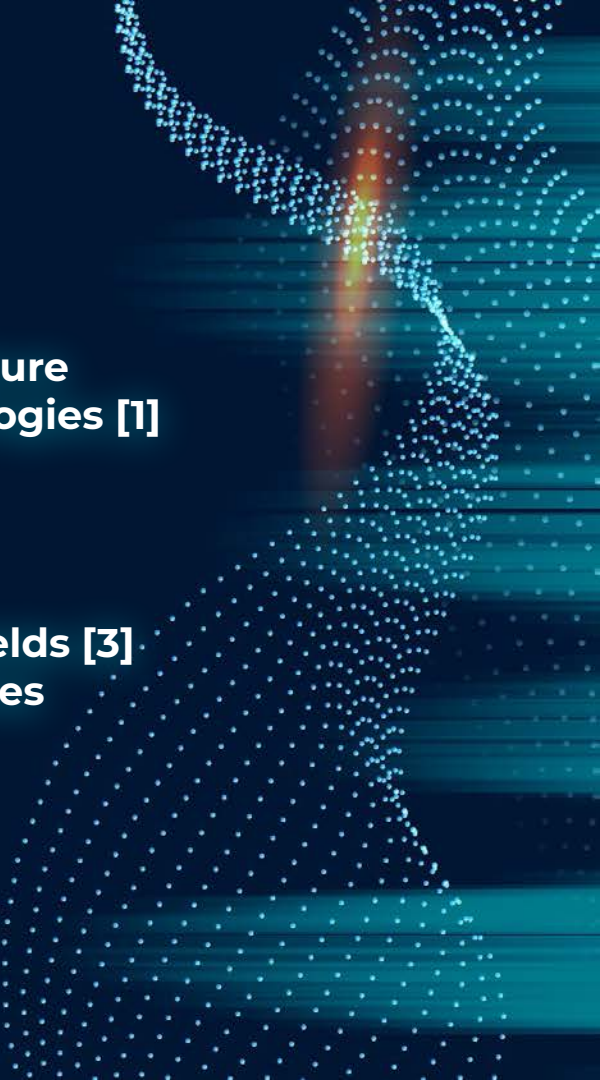
Introduction

Education

- Plays a foundational role in building humanity's future
- Must remain relevant in quickly advancing technologies [1]
- Often lags behind industrial advancements [3]

Innovation

- Traditional teaching methods work in traditional fields [3]
- Technology moves too fast for traditional approaches
- This requires innovative educational ideas



Introduction

Technology

- The pace of change in tech seems to be the problem....
- The use of new technologies could provide a better solution
- Gamification: an interface between advanced tech and education
- Gamification has been shown to facilitate engagement [4]

Cybersecurity

- Cybersecurity operations will increase up to 33% in the next decade [2]
- Technology applications are growing larger and more complex
- Cyber Criminals pose a threat to everyone on the internet [5]

Gamification History



Teachers have been proposing educational computer games since the earliest days of computing systems.



Early games revealed immediate benefits in student engagement and visualization.



Because gamification didn't see widespread use until 2010, the discipline is still *relatively undeveloped*.



Motivation for gamification lies in associating “fun” digital game-like applications with classroom learning activities.



Gamification in Cybersecurity isn't new, but lacks formalized study.

Why Gamification?

4. IMMERSION

Modern video games provide immersive graphics and sensory interfaces. [6]

5. ENGAGEMENT

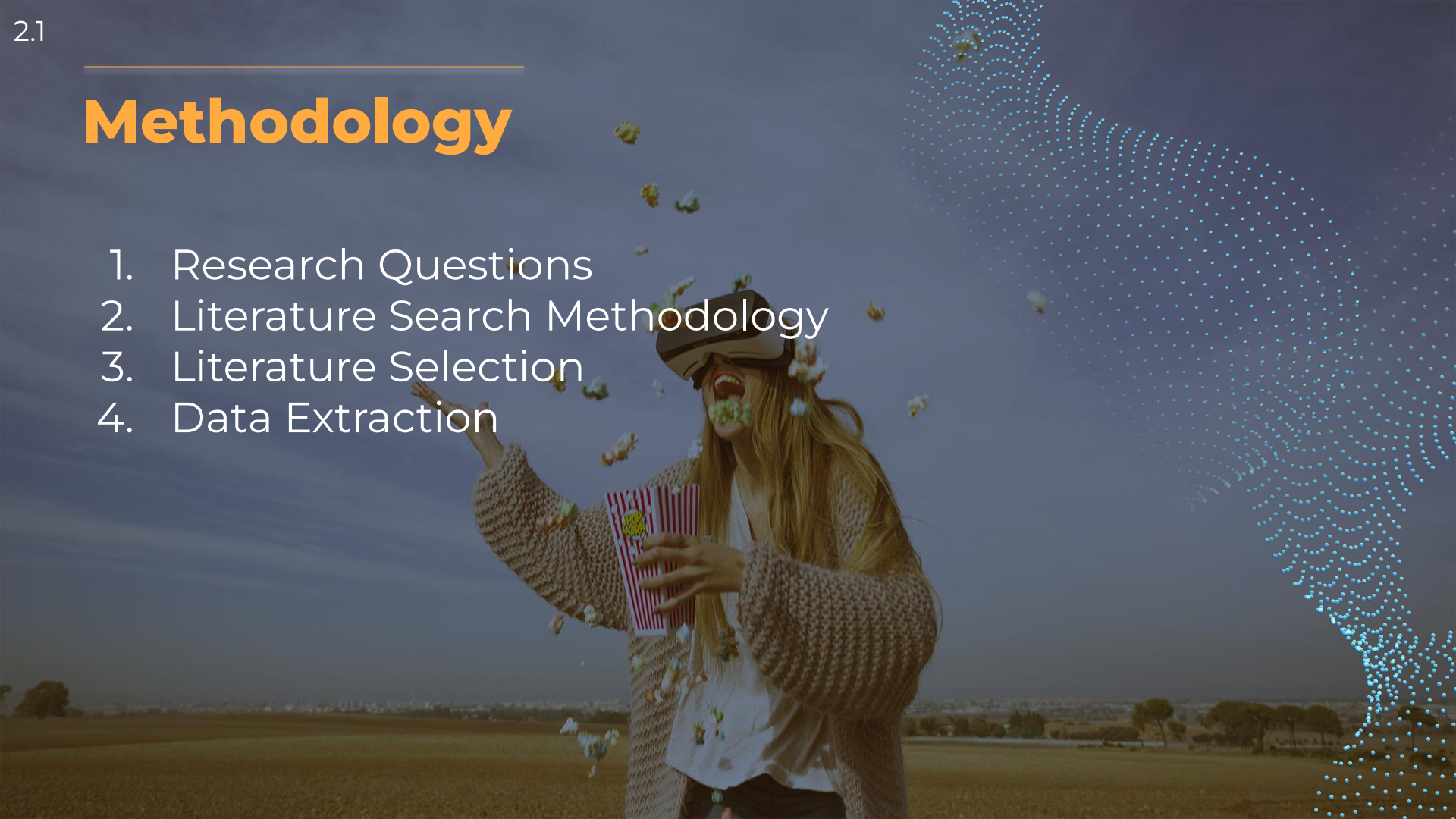
The immersive and enjoyable nature of games create engagement in students. [7]

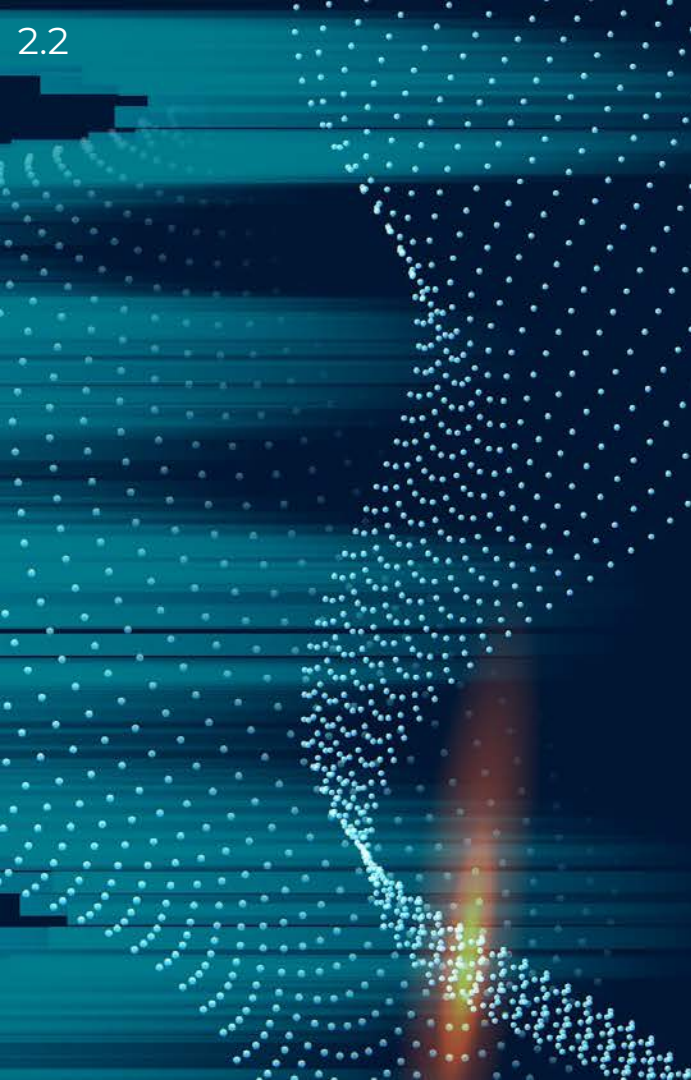
PURPOSE

To methodically collect, review, and discuss existing cybersecurity gamification applications for the purpose of observing emergent patterns.

Methodology

1. Research Questions
2. Literature Search Methodology
3. Literature Selection
4. Data Extraction





Method, Selection, Extraction

- **Logical Search Method**
 - For each keyword combination in each category: Category1 + "AND " + Category2 + " AND " + Category3
 - Snowballing
- **Literature Selection**
 - INCLUDE
 - Research Papers in English, after 2005
 - EXCLUDE
 - Labs, environment studies, competitions, tutorials, panels, short studies, and posters.
 - Papers without an in-class evaluation
- **Extraction**
 - Pertinent papers were read and evaluated for characteristics.

Applications



DATES

The corpus spans from 2007 through June 2022.



TOTAL

A total of 466 applications were found in 4 databases and via snowballing



INCLUDED

74 total papers were found that met the inclusion and exclusion criteria. 80 total applications.

Evaluation

1. No judgement about quality or value is made
2. Only characteristics were recorded for each application evaluated



Characteristics



PURPOSE



ENGAGEMENT



IMMERSION



CONTROL



SOCIAL



SELF-DIRECTED

Discussion



TEST/QUIZ



STORY



VISUALIZATION



SIMULATION



GOAL-DRIVEN



SOCIAL



DYNAMIC

Future Work



Character-based frames for more effective GA classifications



The application of this mapping method to Computer Science GAs for more generalized results.

GROWTH

Gamification in CSO is a very fast growing discipline.

INSIGHT

CSO provides valuable insights as to the focus and intent of gamification in CSO related fields.

HOLISTIC

Findings in CSO GAs should motivate holistic GA evaluations in CSO related fields.

FRAMING

Emergent characteristics provide adequate resolution to support a framing construct.

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Questions

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Thank You!