Developing Tools for Cybersecurity Education and Assessment

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PROBLEM STATEMENT

There is a growing need for highly-trained cybersecurity professionals. Providing the best training possible for the next generation requires continued development of educational tools and techniques. Specifically:

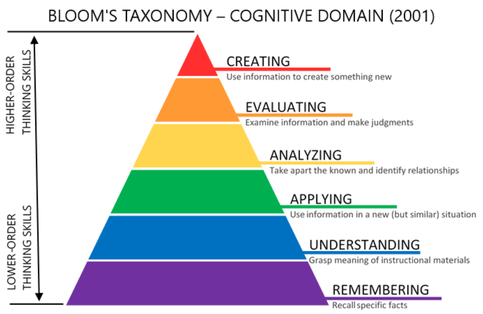
- Established principles and frameworks in education need to be tested in the cybersecurity domain.
- Cybersecurity is a rapidly evolving and highly adversarial domain, making adaptability and creativity key educational components.

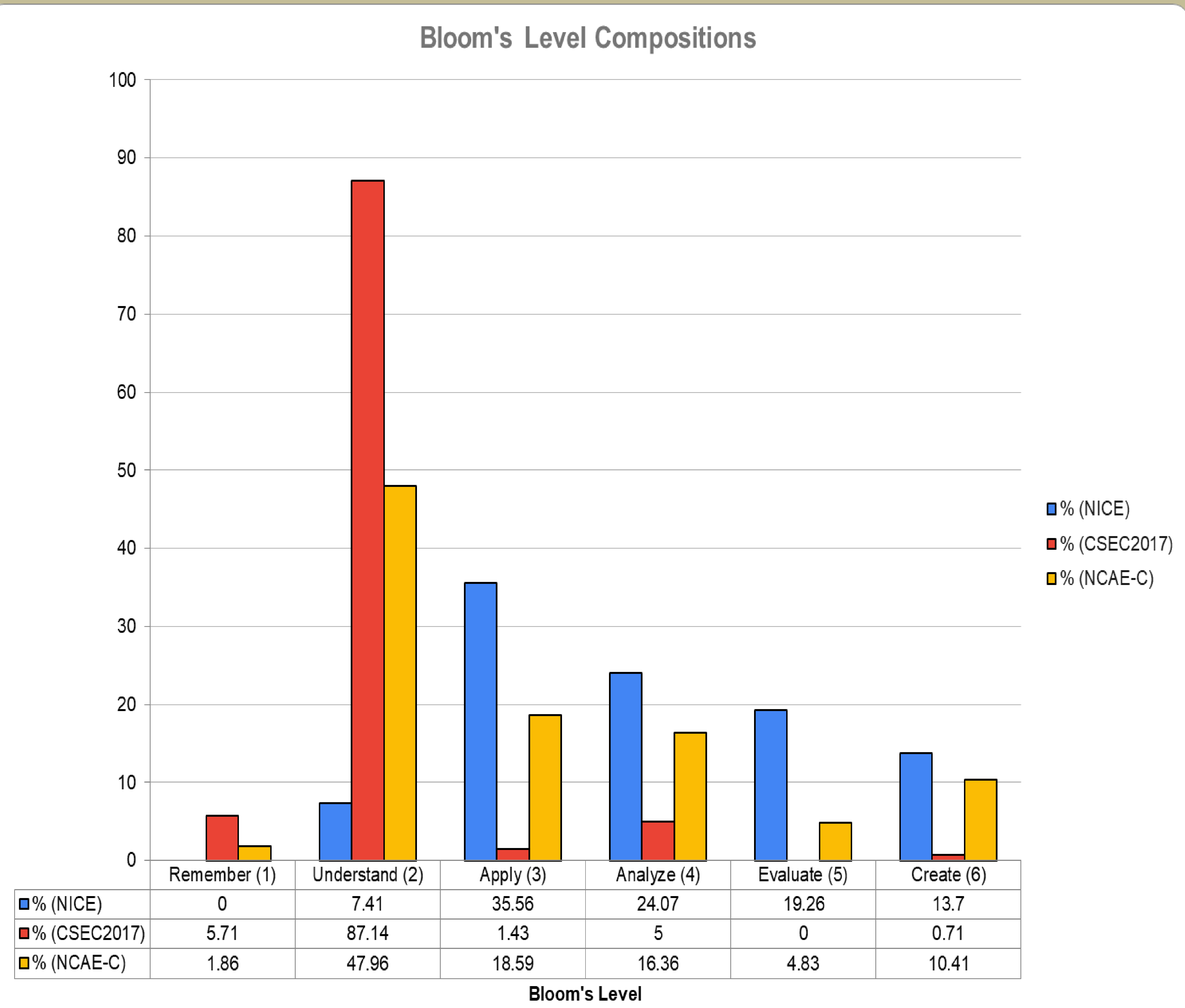
BLOOM'S TAXONOMY

An educational framework for classifying levels of knowledge to develop progressive assessments at each level.

We are using this to develop instructional tools based on assessment of important concepts in cybersecurity.

- **Remember:** To recognize or recall knowledge from memory.
- **Understand:** To construct meaning from material when presented via different formatted messages or activities.
- **Apply:** Carrying out or using a procedure through executing or implementing.
- **Analyze:** Differentiate, organize, and attribute components and functionality of a concept.
- **Evaluate:** Making judgements based on criteria and standards.
- **Create:** Putting elements together, and/or reorganizing them into a new pattern, to form a coherent/functional whole.





	Remember (1)	Understand (2)	Apply (3)	Analyze (4)	Evaluate (5)	Create (6)
% (NICE)	0	7.41	35.56	24.07	19.26	13.7
% (CSEC2017)	5.71	87.14	1.43	5	0	0.71
% (NCAE-C)	1.86	47.96	18.59	16.36	4.83	10.41

Bloom's Level

INDUSTRY RECOMMENDATIONS

There are many Cybersecurity frameworks that are used today to train and prepare cybersecurity professionals entering the workforce. Currently, our research focuses only on three frameworks that are recommended choices from industry sources on important cybersecurity skills and knowledge:

- NICE Framework (National Institute of Standards and Technology)
- Cybersecurity Curricula 2017 Framework (ACM, IEEE, others)
- National Centers for Academic Excellence in Cybersecurity Framework (NSA, FBI, others)

COMPARISON OF RECOMMENDATIONS

- There is a difference between the learning outcomes in the CSEC2017 and the task descriptions in the NICE Framework.
- The CSEC2017 is concentrated at the "Understand" level, while the NICE Framework is more evenly distributed across the higher levels.
- Such differences represents a significant gap between what the CSEC2017 is recommending be taught, and what the NICE Framework says are important professional skills.
- We expect that teaching for assessments at higher bloom's levels will be more effective than teaching courses at lower bloom's levels.

FUTURE DIRECTIONS

The main goals of this work moving forward are:

- Use Bloom's Taxonomy to guide development of learning activities and assessments (Anderson et al, 2001)
- Use Bloom's Taxonomy to evaluate multiple Universities cybersecurity courses to gain more perspective on how integrated the three recommended frameworks (and others) are with such courses
- Design lessons that teach to the assessment while following established instructional design principles for multimedia learning (Mayer & Fiorella, 2022)
- Investigate the efficacy of established instructional design principles when applied to cybersecurity.

Significance

- Evaluate current frameworks, courses, and tools used to train and prepare cybersecurity professionals and identify areas that can be improved upon.
- To develop tools and assessments that align with the learning outcomes of the NICE framework and apply the higher levels of Bloom's Taxonomy.
- Having new educational tools and assessments that improve methods of instruction for cybersecurity education can help train cybersecurity professionals more effectively.

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