An Analysis of Cybersecurity Educational Standards

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Packet Hacking Village @ Def Con 26

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Bio

- Current – Rochester Institute of Technology
  - Lecturer (Mobile / Web / Network Auditing / Penetration Testing)
  - Incoming Undergraduate Coordinator
  - Incoming Undergraduate Curriculum Committee Chair
  - Technical Director, Security Assessment and Forensic Examination (SAFE) Lab
- Past Lives
  - Adjunct Lecturer
  - System Administrator

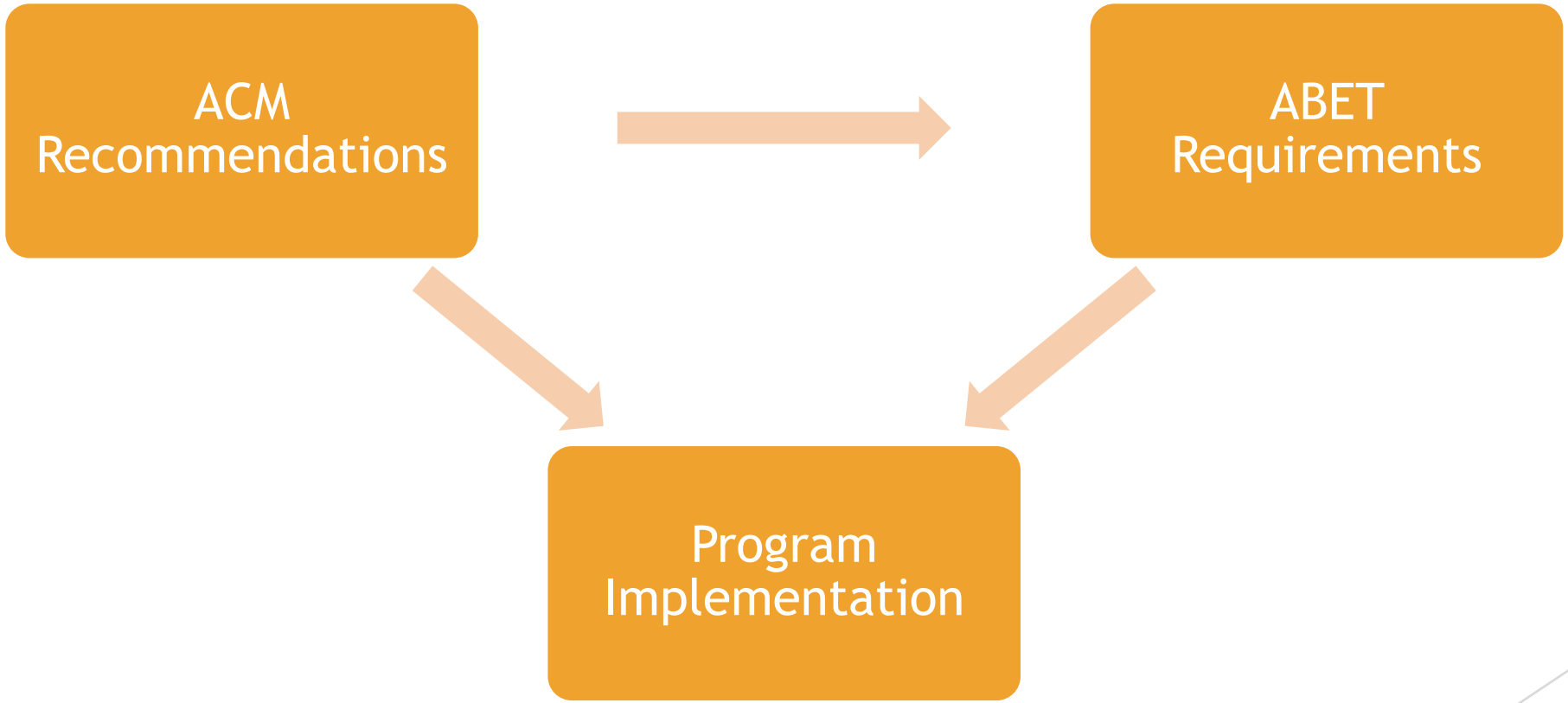
Overview

- Accreditations and Designations in Cybersecurity
- Background on Accreditation and Assessment
- Metrics for Evaluating Standards in Higher Education
- Comparison of Standards
- Conclusions and Recommendations

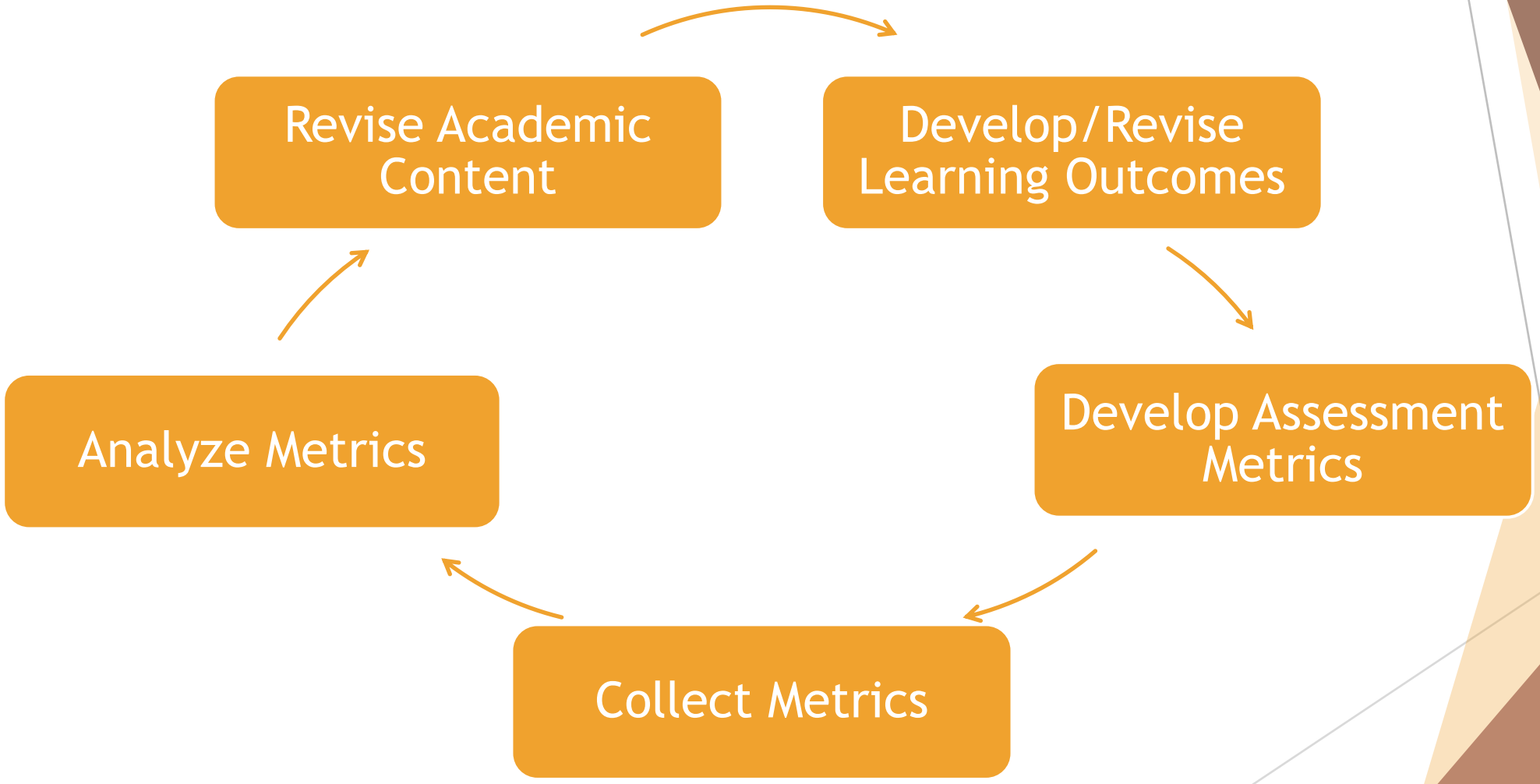
Accreditations and Designations

- Accreditations are independent certifications that a degree program adheres to a curriculum
  - ABET is the primary accrediting agency
  - Available ABET accreditations are:
    - Computer Science
    - Information Technology
    - Information Systems
    - Cybersecurity – The separation between ACM and ABET is unclear
- Designations are independent certifications that a university offers a particular program to students
  - NSA is the primary designating agency
  - Available (curricular) designations are:
    - Center of Academic Excellence – Cyber Defense (4 yr)
    - Center of Academic Excellence – Cyber Operations (Fundamental)

How Curriculum is Usually Made



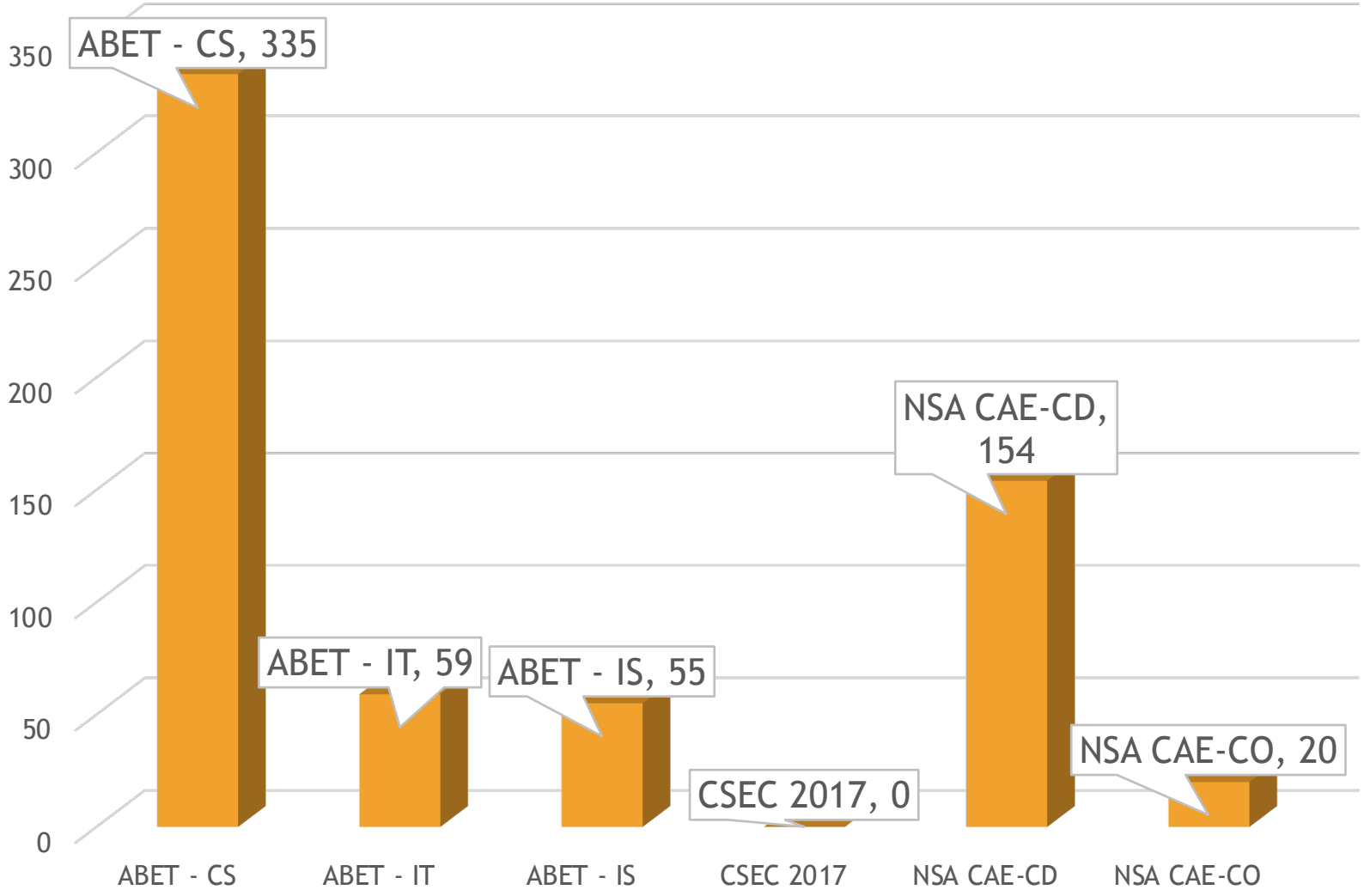
Program Assessment



Metrics for Comparing Programs

- Adoption Rates
  - This is a soft metric for how valuable an accreditation or designation is
  - There are several confounding variables
    - Doesn’t account for the prevalence of different degree programs
    - Doesn’t account for the ease or difficulty of acquiring a designation/accreditation
- Required Technical Content
- Required Non-Technical Content
- Types of Skills Measured in Learning Outcomes
  - Learning outcomes are the lifeblood of accreditation

Adoption Rates



Content Metrics

- Required?
  - Is this topic explicitly required in the accreditation or designation?
- Instructional Hours
  - How much time is dedicated to this topic?
  - Categorizations
    - Significant: Accreditation documents indicate >65% of time is spent on this topic
    - Moderate: Accreditation documents indicate 35%-65% of time is spent on this topic
    - Casual: Accreditation documents indicate <35% of time is spent on this topic
    - Note: These categorizations are subjective
- Is this topic mentioned in learning outcomes?

ABET – CS Curriculum

The curriculum requirements specify topics, but do not prescribe specific courses.

These requirements are:

(a) Computer science: At least 40 semester credit hours (or equivalent) that must include:

1. Substantial coverage of algorithms and complexity, computer science theory, concepts of programming languages, and software development.
2. Substantial coverage of at least one general-purpose programming language.
3. Exposure to computer architecture and organization, information management, networking and communication, operating systems, and parallel and distributed computing.
4. The study of computing-based systems at varying levels of abstraction.
5. A major project that requires integration and application of knowledge and skills acquired in earlier course work.

(b) Mathematics: At least 15 semester credit hours (or equivalent) that must include discrete mathematics and must have mathematical rigor at least equivalent to introductory calculus. The additional mathematics might include course work in areas such as calculus, linear algebra, numerical methods, probability, statistics, or number theory.

(c) At least six semester credit hours (or equivalent) in natural science course work intended for science and engineering majors. This course work must develop an understanding of the scientific method and must include laboratory work.

ABET – IT Curriculum

The curriculum requirements specify topics, but do not prescribe specific courses. The curriculum must include coverage of fundamentals and applied practice in the following:

(a) The core information technologies of human-computer interaction, information management, programming, web systems and technologies, and networking.

(b) System administration and system maintenance.

(c) System integration and system architecture.

ABET – IS Curriculum

The curriculum requirements specify topics, but do not prescribe specific courses.

These requirements are:

(a) Information systems: At least 30 semester credit hours (or equivalent) that include coverage of fundamentals and applied practice in application development; data and information management; information technology infrastructure; systems analysis, design and acquisition; project management; and the role of information systems in organizations.

(b) Information systems environment: At least 15 additional semester credit hours (or equivalent) of a cohesive set of topics that provide an understanding of an information systems environment.

(c) Quantitative analysis or methods that must include statistics.

ABET – CSEC Curriculum

- Knowledge Areas
  - Data Security: Crypto, authentication, privacy
  - Software Security: SSDLC, AppSec, Ethics(?)
  - Component Security: Reverse engineering, security testing, supply chain
  - Connection Security: Physical security, hardware security, network security
  - System Security: Systems engineering, security processes, testing models
  - Human Security: Identity management, social engineering, policy, awareness
  - Organizational Security: Risk, governance, ethics, system administration
  - Societal Security: Cybercrime, law, policy [politics], cyberwar

NSA CAE-CD Curriculum: Core

2 Year Core		4 Year Core (Includes 2 Year Core)
Basic Data Analysis	IT System Components	Databases
Basic scripting or programming	Networking Concepts	Network Defense
Cyber Defense	Policy/Legal/Ethics/Compliance	Network Technology and Protocols
Cyber Threats	System Administration	Operating Systems Concepts
Fundamentals of Security Design Principles		Probability and Statistics
IA Fundamentals		Programming
Intro to Crypto		

NSA CAE-CD Curriculum: Electives

Advanced Cryptography	Software RE	Industrial Control Systems	Data Administration	System Certification and Accreditation	Embedded Systems
Algorithms	Software Sec. Analysis	Mobile Technologies	Database Management	Digital Forensics (Specialties)	Hardware Reverse Engineering
Data Structures	Secure Prog. Practices	Network Security Administration	Digital Comms	Intrusion Detection	Hardware & Firmware Sec
Low Level Programming	Software Assurance	OS Hardening	IA Compliance	Overview of Cyber Operations	RF Principles
Intro to Theory of Comp	Systems Programming	Virtualization Technology	IA Standards	Penetration Testing	Forensic Accounting
Low Level Programming	Advanced Network Technologies	Wireless Sensor Networks	Secure Prog. Management	System Security Engineering	Fraud prevention
OS Theory	Analog Telecomm.	Cloud Computing	Security Risk Analysis	Secure Prog. Practices	Independent/Directed Studies
QA/Functional Testing	IA Architectures	Cybersecurity Mgmt/Planning	Supply Chain Security	Vulnerability Analysis	

NSA CAE-CO: Core Requirements

- Low Level Programming
- Software Reverse Engineering
- Operating Systems Theory
- Networking
- Cellular and Mobile Technologies
- Discrete Math and Algorithms
- Overview of Cyber Defense
- Security Fundamental Principles
- Vulnerabilities
- Law and Ethics

NSA CAE-CO: Electives

1. Programmable Logic
2. Wireless Security
3. Virtualization
4. Cloud Security
5. Risk Management
6. Computer Architecture
7. Microcontroller Design
8. Software Security Analysis
9. Secure Software Development
10. Embedded Systems
11. Digital Forensics
12. Systems Programming
13. Applied Cryptography
14. Industrial Control Systems
15. UX/HCI
16. Offensive Cyber Operations
17. Hardware Reverse Engineering

Technical Content: Programming

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	Yes	Significant	No
ABET – IT	No	N/A	No
ABET – IS	No	N/A	No
CSEC 2017	No	N/A	No
NSA CAE-CD	Yes	Casual	Yes
NSA CAE-CO	Yes	Significant	Yes

Technical Content: Programming

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	Yes	Significant	No
ABET – IT	No	N/A	No
ABET – IS	No	N/A	No
CSEC 2017	No	N/A	No
NSA CAE-CD	Yes	Casual	Yes
NSA CAE-CO	Yes	Significant	Yes

Technical Content: Networking

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	No	N/A	No
ABET – IT	No	N/A	No
ABET – IS	No	N/A	No
CSEC 2017	Yes	Casual-Moderate	Yes
NSA CAE-CD	Yes	Casual-Moderate	Yes
NSA CAE-CO	Yes	Casual	Yes

Technical Content: System Administration

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	No	N/A	No
ABET – IT	No	Moderate-Significant	No
ABET – IS	No	N/A	No
CSEC 2017	Yes	Casual	No
NSA CAE-CD	Yes	Casual-Moderate	Yes
NSA CAE-CO	Yes	Casual-Moderate	Yes

Technical Content: Cryptography

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	No	N/A	No
ABET – IT	No	N/A	No
ABET – IS	No	N/A	No
CSEC 2017	Yes	Casual-Moderate	No
NSA CAE-CD	Yes	Casual	Yes
NSA CAE-CO	No	Casual	Yes

Non-Technical Content: Risk

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	No	N/A	No
ABET – IT	No	N/A	No
ABET – IS	No	N/A	No
CSEC 2017	Yes	Significant	No
NSA CAE-CD	No	Casual	Yes
NSA CAE-CO	No	Casual	Yes

Non-Technical Content: Security Policy

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	No	N/A	No
ABET – IT	No	N/A	No
ABET – IS	No	N/A	No
CSEC 2017	Yes	Casual	Yes
NSA CAE-CD	Yes	Casual	Yes
NSA CAE-CO	No	N/A	Yes

Non-Technical Content: Information Security Management

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	No	N/A	No
ABET – IT	No	N/A	No
ABET – IS	No	N/A	No
CSEC 2017	Yes	Casual	Yes
NSA CAE-CD	Yes	Casual	Yes
NSA CAE-CO	No	N/A	Yes

Non-Technical Content: Privacy

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	No	N/A	No
ABET – IT	No	N/A	No
ABET – IS	No	N/A	No
CSEC 2017	Yes	Significant	No
NSA CAE-CD	Yes	Casual	Yes
NSA CAE-CO	No	N/A	No

Non-Technical Content Required: Ethics

PROGRAM	REQUIRED?	INSTRUCTIONAL HRS	Outcome?
ABET – CS	Yes*	Casual	Yes
ABET – IT	Yes*	Casual	Yes
ABET – IS	Yes*	Casual	Yes
CSEC 2017	Yes	Casual-Moderate	Yes
NSA CAE-CD	Yes	Casual	Yes
NSA CAE-CO	Yes**	Casual	Yes

* ABET programs have a generic learning outcome that applies to all programs
** CAE-CO has a trivial amount of ethics compared with law

Types of Learning Outcomes

Analyze
Describe
Development

Create
Build
Implement

ABET – CS
ABET – IS
ABET – IT
CSEC 2017

NSA CAE-CD
NSA CAE-CO

Conclusions

- CSEC 2017 does a better job at addressing core security topics than other academic accreditations
  - Learning outcomes are largely connected to soft skills
- ABET – CS, the most prevalent accreditation, has the fewest core security skills
- NSA CAE-CO seems to push core technical skills at the expense of core non-technical skills
- NSA CAE-CD seems extremely broad, but it does require the most core skills and connects them to learning objectives that test hard skills.

References

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