Cybersecurity Educational Standards

Stephen Cooper, Stanford University
Elizabeth Hawthorne, Union County College
Lance C. Pérez, University of Nebraska - Lincoln
Susanne Wetzel, Stevens Institute of Technology
Background

• In response to the White House’s 60-day Cybersecurity Review, information assurance (IA) education assumed renewed priority at DHS, NSA, and NSF
  o DHS – interested in an Essential Body of Knowledge (www.us-cert.gov/ITSecurityEBK/)
  o NSA/DHS – co-owners of the CAE designation
  o DoD – Information Assurance Scholarship Program
  o NSF – Scholarship For Service Program

• Fundamental Question
  o Are U.S. IA educational programs sufficient to meet the emerging needs of industry or government?
Additional Questions

• Is the CAE/IAE designation appropriate for all institutions offering IA educational programs?
• What is the source and history of IA training and educational efforts?
• Is there enough coherence between existing IA educational efforts to consider developing a BoK?
• What is the variety of IA degree programs at different institutions (2-year, 4-year, graduate)?
ITiCSE “Working Groups”

• “working group”
  o term used by ITiCSE for small groups examining a particular question
  o different from standards working groups, e.g., ACM, IEEE, ANSI, NIST, etc.

• NSF funded a series of three “working groups”:
  o ITiCSE 2009 “An Exploration of the Current State of Information Assurance Education”
  o ITiCSE 2010 “Towards Information Assurance (IA) Curricular Guidelines”
  o ITiCSE 2011 “Information Assurance Education in Two and Four-Year Institutions”

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2009 ITiCSE

An Exploration of the Current State of Information Assurance Education
Members

- Steve Cooper, leader
- Christine Nickel, co-leader
- Victor Piotrowski
- Brenda Oldfield
- Ali Abdallah
- Matt Bishop
- Bill Caelli
- Melissa Dark
- Elizabeth Hawthorne
- Lance Hoffman
- Lance C. Pérez
- Charles Pfleeger
- Richard Raines
- Corey Schou
- Joel Brynielsson
Charge

• Explore and document the space of various existing IA educational standards and guidelines
• Examine these standards and guidelines in the context of other curricular guidelines in computing
Some Documents Examined

- Information Technology 2008, Curriculum Guidelines for Undergraduate Degree Programs in Information Technology
- Software Engineering 2004, Curriculum Guidelines of Undergraduate Degree Programs in Software Engineering
  http://sites.computer.org/ccse
- The CORE Body of Knowledge for Information Technology Professionals
- Computing Curricula 2009: Guidelines for Associate-Degree Transfer Curriculum in Computer Science
  http://www.acmtyc.org/WebReports/CSreport/
- CAE Program Requirements http://www.nsa.gov/ia/academic_outreach/nat_cae/cae_iae_program_criteria.shtml

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Outcomes

• Historical context for IA
• Review of assessment and accreditation practices of current education
• IA is a discipline in its own right
Findings

• Need for governing body (e.g., ACM or IEEE) to develop educational guidelines (2-year, 4-year and graduate levels)

• Facilitation of articulation from the lower academic division (associate degree) into the upper academic division (baccalaureate degree)

• Government, industry and academia must work together to increase the IA faculty pipeline
Towards Information Assurance (IA) Curricular Guidelines
Members

- Steve Cooper, leader
- Christine Nickell, co-leader
- Lance C. Pérez, co-leader
- Brenda Oldfield, co-leader
- Joel Brynielsson
- Asım Gençer Gökce
- Beth Hawthorne
- Karl Klee
- Andrea Lawrence
- Susanne Wetzel

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Charge

• Explore the feasibility of defining a body of knowledge (BoK) for IA education
• Demonstrate the feasibility of defining appropriate and comprehensive student learning outcomes for a sample subject in the proof-of-concept BoK for IA education
Starting Point

• Survey:
  o Based on the ten CISSP knowledge domains
  o Sent to all CAE-IAE/CAE-R/CAE2Y institutions during CISSE and left open up to ITiCSE 2010
  o Approximately 30 responses
Survey of IA Areas

• Fundamental Concepts
• Cryptography
• Security Ethics
• Security Policy
• Digital Forensics
• Access Control
• Security Architecture and Systems
• Network Security
• Risk Management
• Attacks/Defenses
• Secure Software Design and Engineering
• Operational Issues
Outcomes

• Survey results
  o Areas comprehensive
  o Some differences (current vs. ideal):
    – Increase: Ethics; Policy; Digital Forensics; Secure Software Design and Engineering
    – Decrease: Network Security; Attacks/Defense; Access Control
  o Operational Issues was absorbed into other areas
Outcomes Continued

- Determined sample subjects within each area of the proof-of-concept BoK, e.g.,
  - Secure Software Design and Engineering
    - Secure Software Specification
    - Secure Coding
    - Secure Testing
    - Program verification and simulation
    - Language-based Security
    - Secure Design
    - Maintenance
Outcomes Continued

• Sample description for sample subject Secure Coding based on student learning outcomes:
  – Detailed description of topics:
    • Quick definition
    • Key principles
    • Examples/common issues
  – Use verbs from Bloom’s Taxonomy (from AS CS Degree Transfer document) to specify learning outcomes
  – Categorize outcomes as core or elective
  – Add assessment rubric for learning outcomes
  – Mapping of outcomes to topics

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Findings

• International community should define a BoK based on student learning outcomes
• International community should define location of programs w.r.t. various disciplines
• International community should define pathways, especially between 2-year colleges and 4-year institutions
2011 ITiCSE

IA Education at Two- and Four-Year Institutions
Members

- Lance C. Pérez, leader
- Stephen Cooper, co-leader
- Elizabeth Hawthorne, co-leader
- Susanne Wetzel, co-leader
- Joel Brynielsson
- Asım Gençer Gökce
- John Impagliazzo
- Youry Khmelevsky
- Karl Klee
- Margaret Leary
- Amelia Philips
- Norbert Pohlman
- Blair Taylor
- Shambhu Upadhyaya
Charge

• Identify examples of undergraduate IA curricula
  – two- and four-year level
  – both within and outside the U.S.
• Identify articulation challenges
• Provide recommendations for moving forward
IA Education Outside the U.S.

- Few equivalent to U.S. associate-degree programs
- Most IA programs reside at the post-graduate level
- Examined 7 baccalaureate degree programs
# Non-U.S. Bachelor Degree Programs

<table>
<thead>
<tr>
<th>Country</th>
<th>Institution</th>
<th>Bachelor Program Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>Seneca</td>
<td>Informatics and Security</td>
</tr>
<tr>
<td>Germany</td>
<td>Bochum</td>
<td>IT Security</td>
</tr>
<tr>
<td>Germany</td>
<td>Offenburg</td>
<td>IT Security</td>
</tr>
<tr>
<td>Malaysia</td>
<td>University of Technology Malaysia</td>
<td>Computer Network Security</td>
</tr>
<tr>
<td>Russia</td>
<td>Moscow Institute of Physics and Technology (MFTI) – PhysTech</td>
<td>Informatics and Security</td>
</tr>
<tr>
<td>Sweden</td>
<td>Blekinge</td>
<td>Security Engineering</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>East London</td>
<td>Information Security Systems</td>
</tr>
</tbody>
</table>
IA Education at 4-Year U.S. Colleges

• 73 CAE institutions offer baccalaureate degrees with IA concentration or minors
  – 42 in CS departments
  – 16 in CIS departments
  – 6 in Security departments
  – 5 in IT departments
  – 4 in Informatics schools/departments
  – 3 in Electrical and Computer Engineering departments
  – 1 in Software Engineering department
  – 1 in Criminal Justice department
<table>
<thead>
<tr>
<th>Institution</th>
<th>Degree Type</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towson University (CAE/IAE)</td>
<td>BS</td>
<td>Computer Science with a Security Track</td>
</tr>
<tr>
<td>Kennesaw State University (CAE/IAE)</td>
<td>BS</td>
<td>Information Security and Assurance</td>
</tr>
<tr>
<td>Rochester Institute of Technology (CAE/IAE)</td>
<td>BS</td>
<td>Information Security and Forensics</td>
</tr>
<tr>
<td>Stevens Institute of Technology (CAE/IAE, CAE-R)</td>
<td>BS</td>
<td>Cybersecurity</td>
</tr>
<tr>
<td>Mercy College, New York</td>
<td>BS</td>
<td>Cybersecurity</td>
</tr>
<tr>
<td>Pennsylvania College of Technology</td>
<td>BS</td>
<td>Information Technology</td>
</tr>
<tr>
<td>University of Wilmington</td>
<td>BS</td>
<td>Computer and Network Security</td>
</tr>
<tr>
<td>University of Texas, San Antonio (CAE/IAE, CAE-R)</td>
<td>BBA</td>
<td>Infrastructure Assurance</td>
</tr>
<tr>
<td>Oklahoma State University Institute of Technology</td>
<td>BT</td>
<td>Information Assurance and Forensics</td>
</tr>
</tbody>
</table>
IA Education at 2-Year U.S. Colleges

• 16 programs examined
  o 14 AAS degree programs
    • workforce-oriented
  o 2 AS degree programs
    • transfer-oriented

• Combination of CAE2Y and non-CAE2Y
## Associate-degree Programs Examined

<table>
<thead>
<tr>
<th>Institution</th>
<th>Degree Type</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owens Community College (CAE2Y)</td>
<td>AAB</td>
<td>System Security and Information Assurance</td>
</tr>
<tr>
<td>Anne Arundel Community College (CAE2Y)</td>
<td>AAS</td>
<td>Information Assurance and Cybersecurity</td>
</tr>
<tr>
<td>The Community College of Baltimore County (CAE2Y)</td>
<td>AAS</td>
<td>Information Systems Security</td>
</tr>
<tr>
<td>Ashville Buncomb Technical Community College</td>
<td>AAS</td>
<td>Information Systems Security</td>
</tr>
<tr>
<td>Craven Community College</td>
<td>AAS</td>
<td>Information Systems Security</td>
</tr>
<tr>
<td>Gwinnett Technical College</td>
<td>AAS</td>
<td>Information Security Specialist</td>
</tr>
<tr>
<td>Bossier Parish Community College</td>
<td>AAS</td>
<td>Information Network Security Specialist</td>
</tr>
<tr>
<td>Northern Virginia Community College</td>
<td>AAS</td>
<td>Information Systems Technology with a Network Security</td>
</tr>
</tbody>
</table>

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### Associate-Degree IA Programs cont’d

<table>
<thead>
<tr>
<th>Institution</th>
<th>Degree Type</th>
<th>Program Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whatcom Community College (CAE2Y)</td>
<td>AS Technical</td>
<td>Computer Information Systems with a Network Security concentration</td>
</tr>
<tr>
<td>Highline Community College</td>
<td>AAS</td>
<td>Networking Specialist</td>
</tr>
<tr>
<td>Highline Community College</td>
<td>AAS</td>
<td>Data Recovery/ Forensics Specialist</td>
</tr>
<tr>
<td>Hagerstown Community College (CAE2Y)</td>
<td>AAS</td>
<td>Information Systems Technology with a Computer Forensics concentration</td>
</tr>
<tr>
<td>Broome Community College</td>
<td>AAS</td>
<td>Computer Security and Forensics</td>
</tr>
<tr>
<td>Oklahoma City Community College (CAE2Y)</td>
<td>AAS</td>
<td>Computer Science Cyber/Information Security concentration</td>
</tr>
<tr>
<td>Oklahoma City Community College (CAE2Y)</td>
<td>AS</td>
<td>Computer Science Cyber/Information Security University Parallel</td>
</tr>
<tr>
<td>Harrisburg Area Community College</td>
<td>AS</td>
<td>Computer Information Security</td>
</tr>
</tbody>
</table>

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IA Education at 2-Year U.S. Colleges

• Two examples of AAS degrees
  o Network Security
  o Digital Forensics
AAS IA degree - Network Security
(66 credits)

Technical
Ethics
Supporting
General Education

Network
Fundamentals
Digital Forensics
Capstone

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AAS IA degree - Digital Forensics (65 credits)

- Criminal Justice
- Technical
- Security
- General Education
- Supporting

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AS designed to transfer into BS
Computer Science with a IA track
(65 credits)
Findings

• Articulation Challenges for AAS programs
  – Insufficient math and science
  – Level of technical courses
• Few AAS degree programs transfer into applied BS degree programs
• AS degree programs transfer into BS “CS with IA track” degree programs
Findings Continued

• Increasing variety of IA degree programs at each education level

• Articulation between 2-year and 4-year degree programs still challenging
Summary and Recommendations

• A sequence of three ACM ITiCSE working groups explored
  – The history of IA education
  – The feasibility of defining a BoK for IA
  – The variety of IA degree programs in a broad international context

• IA community needs an international effort to define a set of educational guidelines
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