Toward Competent Computer Science Graduates

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Professional Competencies in Computing Education: Pedagogies and Assessment

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Brief Bio

- Middleware expertise
  - ~9 years of software development and management building private cloud infrastructures for near-real-time global financial applications
- Recent research
  - Applying data science and cybersecurity to critical infrastructure protection
- Computing education
  - ABET's Computing Accreditation Commission (CAC)
    - CAC Criteria Committee Chair 2016-19, CAC Chair-Elect
  - ACM/IEEE-CS/AAAI CS202X Task Force Co-Chair
    - Decennial rewrite of Computer Science curricular guidelines, probably to be released 2024?

Motivators for Ongoing Work

➡ Societal changes, pre- and post-pandemic
  ➡ Competency-based certificates and education
  ➡ Stackable credentials
➡ Competence of Computer Science graduates
  ➡ Changes in computing education
  ➡ CS202X Curricular Guidelines Task Force
➡ Employer needs to drive curricular change
  ➡ NSF IUSE (Institutional & Community Transformation) Grant
    ➡ U Alabama, GWU, Mississippi State U, Purdue, RIT, Tuskegee, UNH, and UIUC, with Shelton State Community College
      ➡ Awards 2111435, 2110771, 2110815, 2110823, 2110788, 2111157, 2111097, 2110850
   ➡ Support a much more diverse student body and workforce

To build sustainable software, you need ***competent*** programmers!

Underlying Assumption

Competence?

➡ Dictionary definitions

➡ Possession of sufficient knowledge or skill

➡ Important skill needed to do a job

➡ Quality of being adequately or well qualified physically and intellectually

US Secondary & Post-Secondary Credentials

Counting U.S. Postsecondary and Secondary Credentials

Credential Engine

February 2021

www.credentialengine.org
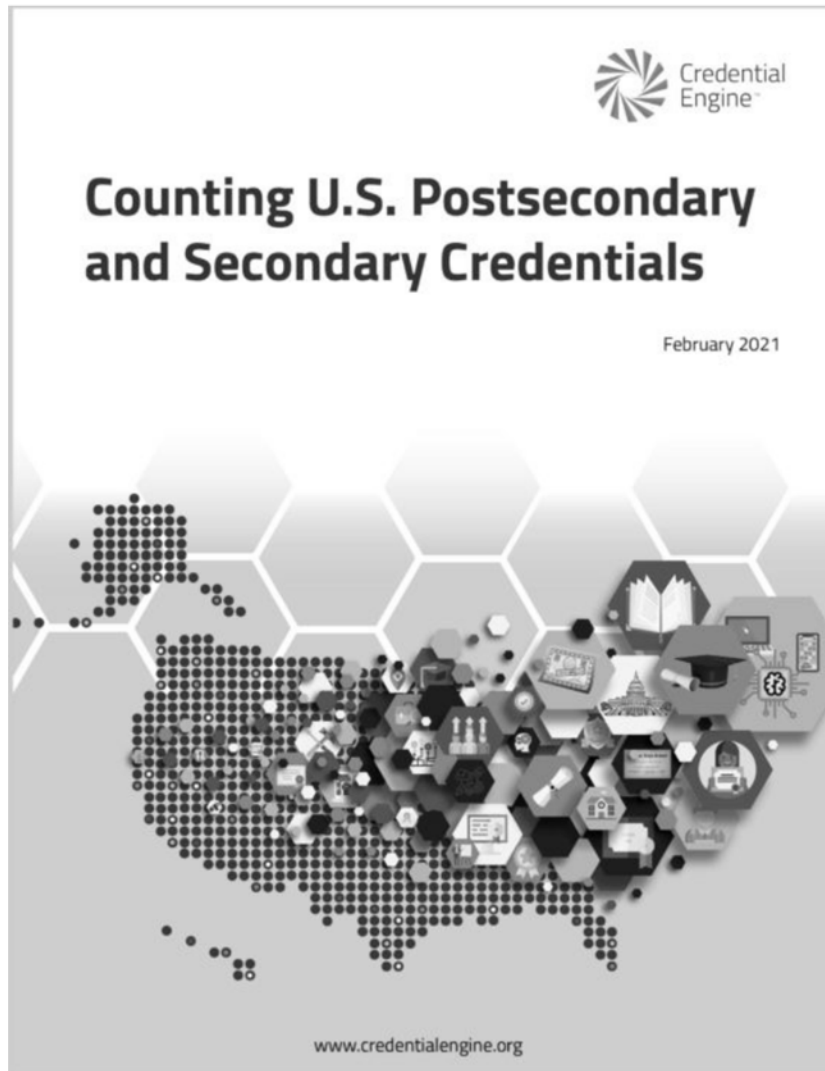
➡ US has 967,734 unique credentials

  ➡ Postsecondary institutions

    ➡ 359,713 degrees and certificates

  ➡ MOOC providers

    ➡ 9,390 certificates, micro-credentials, and foreign online degrees

  ➡ Non-academic providers

    ➡ 549,712 badges, certificates, licenses, certifications, and apprenticeships

  ➡ Secondary schools

    ➡ 48,919 diplomas from public and private secondary schools
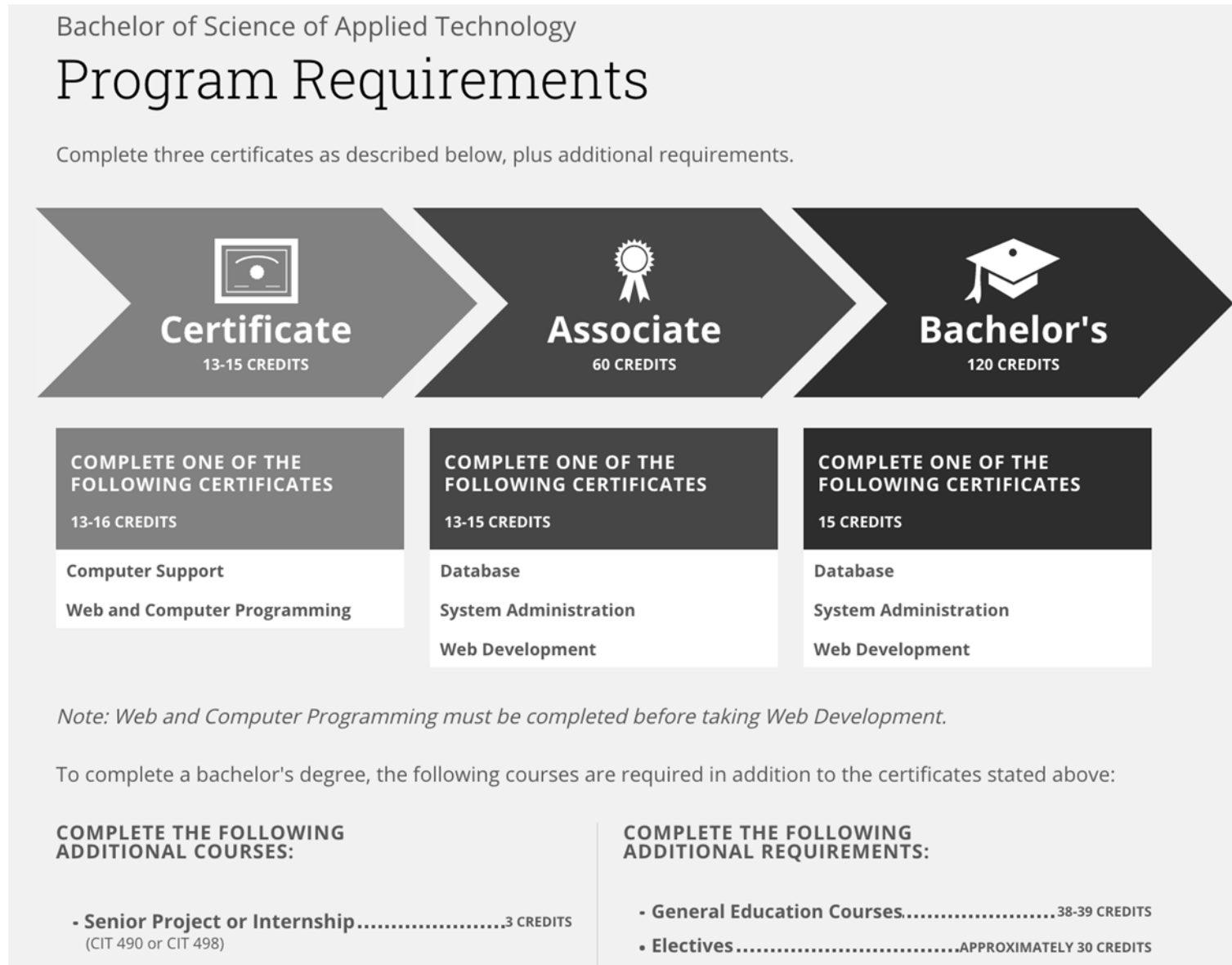
Stackable Credentials
Competency-Based Education

- Competence, one bite at a time
- Many institutions are developing "pathway" programs
  - BYU-Pathway
  - Colorado State Global
  - Purdue Global
  - Western Governors University
  - Wichita State University
  - And many others
- Students complete several certificates toward a full degree
  - If education is disrupted, the student retains certificates as partial successes
  - Industry engagement can lead to credential acceptance for certain types of employment
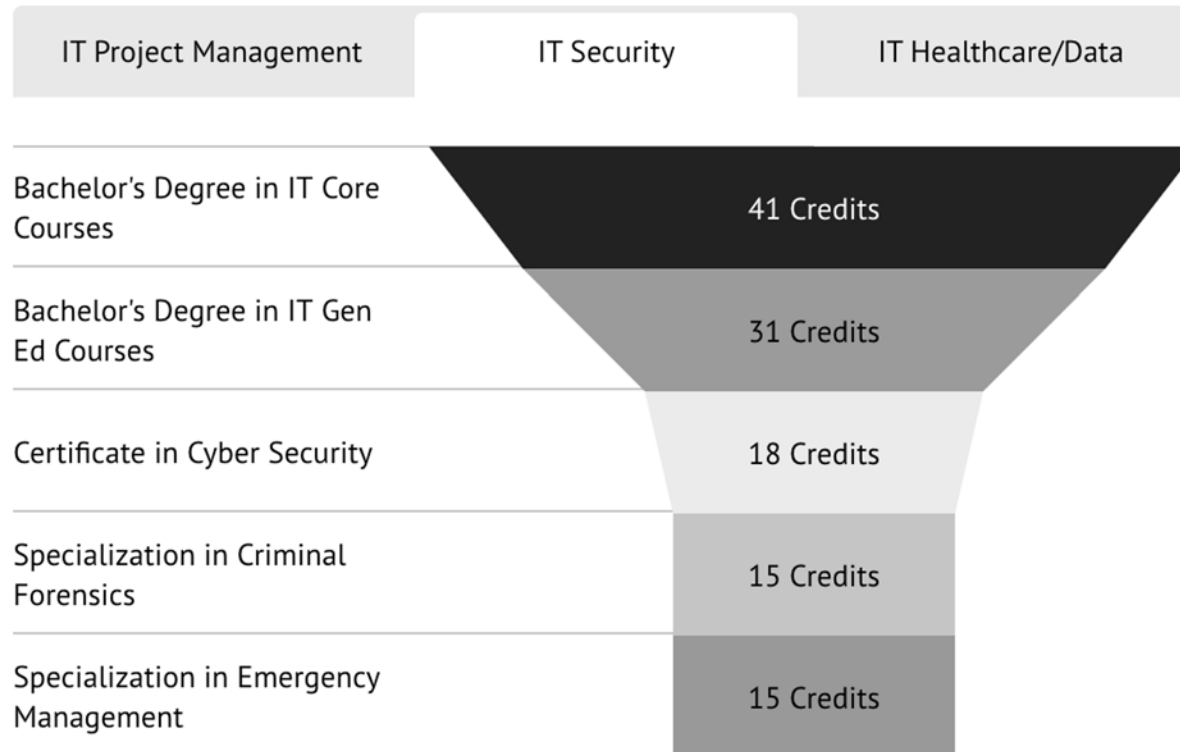- Some employers have also entered this space

BYU Pathways – Example

Bachelor of Science of Applied Technology

Program Requirements

Complete three certificates as described below, plus additional requirements.

Certificate 13-15 CREDITS	Associate 60 CREDITS	Bachelor's 120 CREDITS
COMPLETE ONE OF THE FOLLOWING CERTIFICATES 13-16 CREDITS	**COMPLETE ONE OF THE FOLLOWING CERTIFICATES** 13-15 CREDITS	**COMPLETE ONE OF THE FOLLOWING CERTIFICATES** 15 CREDITS
Computer Support	Database	Database
Web and Computer Programming	System Administration	System Administration
	Web Development	Web Development

Note: Web and Computer Programming must be completed before taking Web Development.

To complete a bachelor's degree, the following courses are required in addition to the certificates stated above:

COMPLETE THE FOLLOWING ADDITIONAL COURSES:

- Senior Project or Internship......................3 CREDITS
  (CIT 490 or CIT 498)

COMPLETE THE FOLLOWING ADDITIONAL REQUIREMENTS:

- General Education Courses......................38-39 CREDITS
- Electives..................................APPROXIMATELY 30 CREDITS

CSU Global – Example

BACHELOR'S EXAMPLES

Example: Information Technology

IT Project Management	IT Security	IT Healthcare/Data

Bachelor's Degree in IT Core Courses	41 Credits
Bachelor's Degree in IT Gen Ed Courses	31 Credits
Certificate in Cyber Security	18 Credits
Specialization in Criminal Forensics	15 Credits
Specialization in Emergency Management	15 Credits

Competence needs to be a transferable currency

To support flexible pathways

Drilling Down Into *Competent* Computer Science Graduates

Where We Are and Where We Need To Go

ACM/IEEE-CS CS2013 Curricular Guidelines

Computer Science Curricula 2013

Curriculum Guidelines for
Undergraduate Degree Programs
in Computer Science

December 20, 2013

The Joint Task Force on Computing Curricula
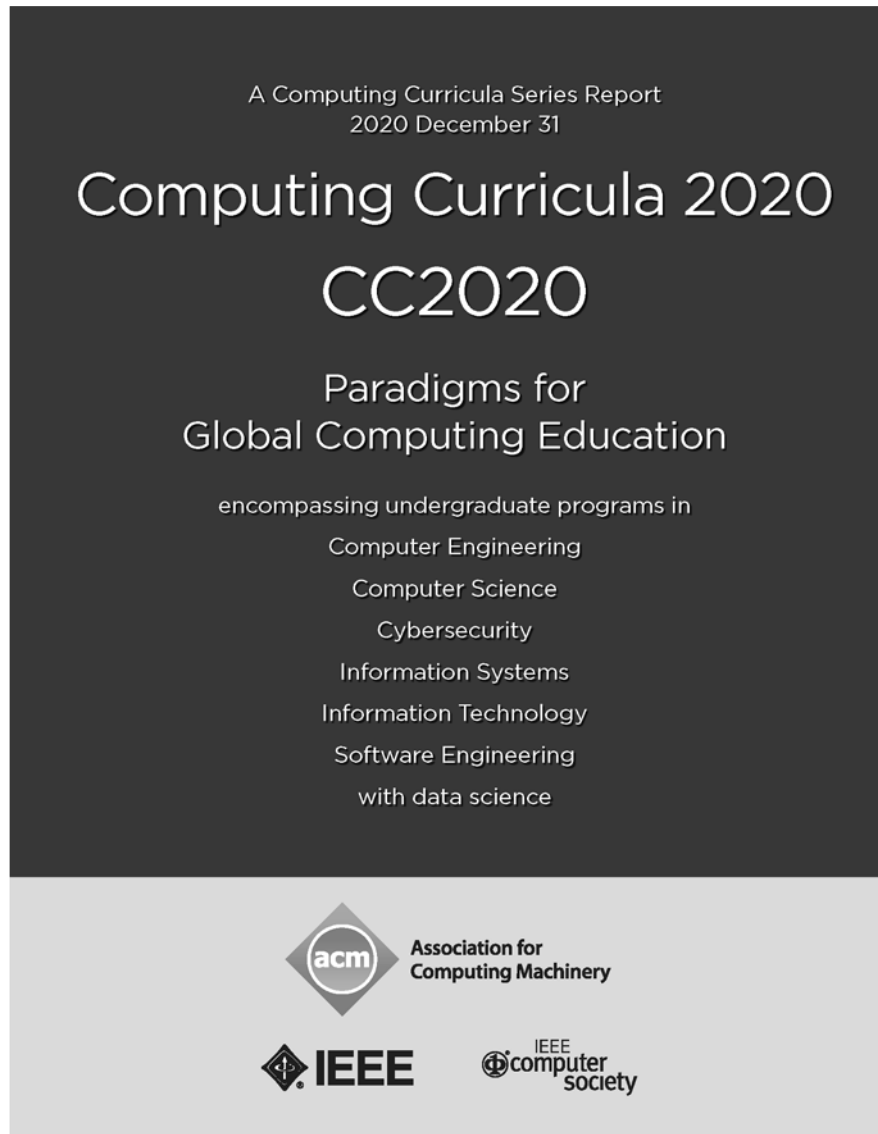Association for Computing Machinery (ACM)
IEEE Computer Society

A Cooperative Project of

Association for Computing Machinery
Advancing Computing as a Science & Profession

IEEE

IEEE computer society

| Knowledge Area	CS2013 Tier1	CS2013 Tier2	CS2008 Core	CC2001 Core
AL-Algorithms and Complexity	19	9	31	31
AR-Architecture and Organization	0	16	36	36
CN-Computational Science	1	0	0	0
DS-Discrete Structures	37	4	43	43
GV-Graphics and Visualization	2	1	3	3
HCI-Human-Computer Interaction	4	4	8	8
IAS-Information Assurance and Security	3	6	--	--
IM-Information Management	1	9	11	10
IS-Intelligent Systems	0	10	10	10
NC-Networking and Communication	3	7	15	15
OS-Operating Systems	4	11	18	18
PBD-Platform-based Development	0	0	--	--
PD-Parallel and Distributed Computing	5	10	--	--
PL-Programming Languages	8	20	21	21
SDF-Software Development Fundamentals	43	0	47	38
SE-Software Engineering	6	22	31	31
SF-Systems Fundamentals	18	9	--	--
SP-Social Issues and Professional Practice	11	5	16	16
Total Core Hours	**165**	**143**	**290**	**280**

|	
All Tier1 + All Tier2 Total	308
All Tier1 + 90% of Tier2 Total	293.7
All Tier1 + 80% of Tier2 Total	279.4

Toward Competence

A Computing Curricula Series Report
2020 December 31

Computing Curricula 2020
CC2020

Paradigms for
Global Computing Education

encompassing undergraduate programs in

Computer Engineering

Computer Science

Cybersecurity

Information Systems

Information Technology

Software Engineering

with data science

acm Association for
Computing Machinery

◆ **IEEE**   IEEE
computer
society

- ➥ Knowledge
  - ➥ "know-what"
- ➥ Skills
  - ➥ "know-how"
- ➥ [Professional] Dispositions
  - ➥ "know-why"

Competency = [Knowledge + Skills + Dispositions]
in Task
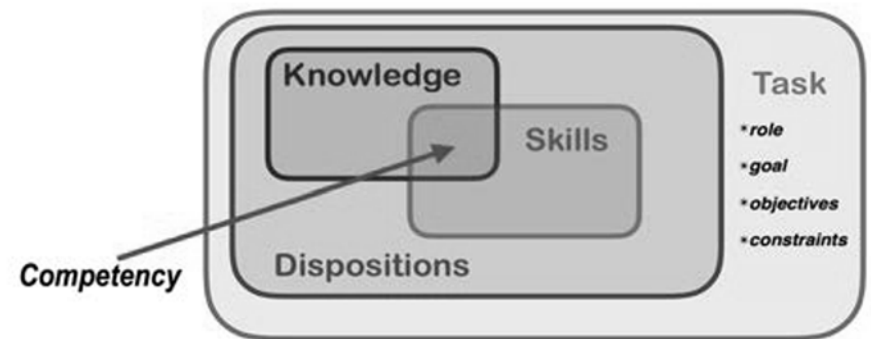
Healthcare Professional Competence: Captured by [Amended] Miller's Pyramid
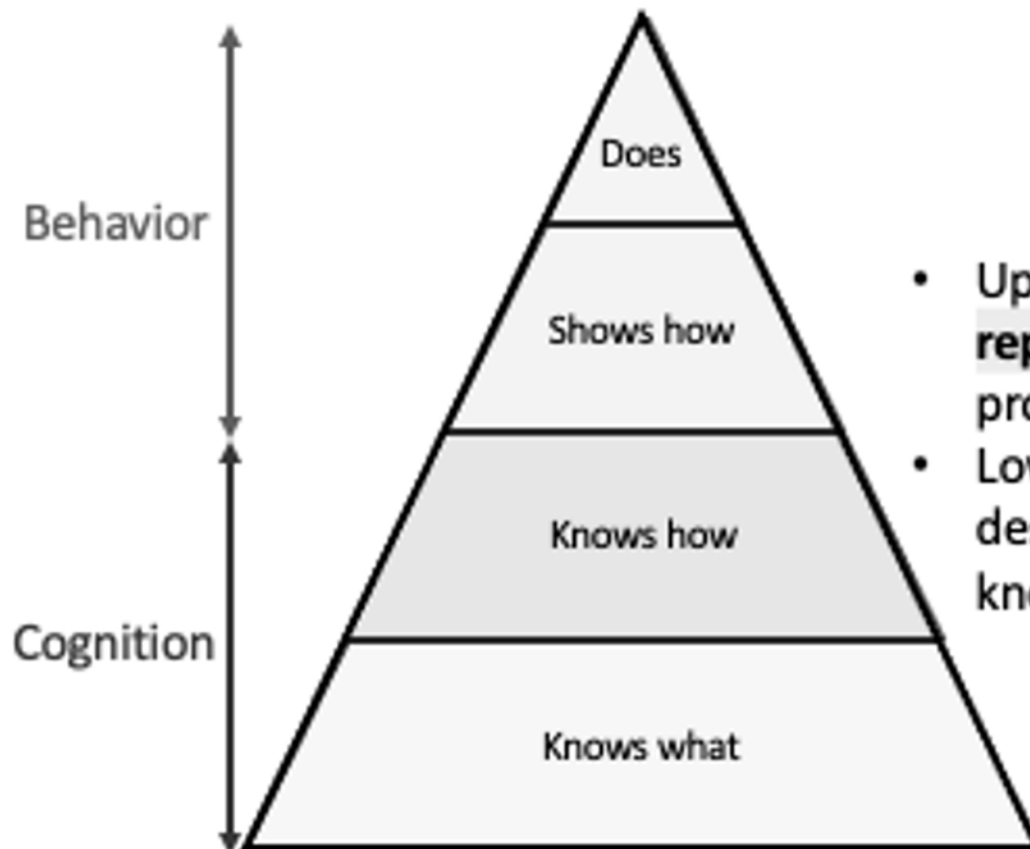
- Upper levels, reflect behaviors, describing **repeated practice** to consolidate and attain professional competence
- Lower levels reflect Bloom competencies, describing acquisition and application of knowledge (knowledge and skill)

Signature Pedagogies and Competence

➤ Capture how to prepare future practitioners in professional programs

  ➤ Meet academic standards of the program

  ➤ Shape character of future practice

  ➤ Convey its values and expectations

➤ Three dimensions of student competencies

  ➤ Think like a professional

  ➤ Perform like a professional

  ➤ Act responsibly and with integrity

Is Computing a Profession?

Assessing Computing Competencies

➡ Assessment of knowledge

   ➡ Been done forever

➡ Assessment of computing skills

   ➡ Sparingly done in isolation

➡ Assessment of professional dispositions

   ➡ Most challenging still

   ➡ Formative versus summative

➡ Assessment of workplace competencies

   ➡ Ultimate context for skills + dispositions

   ➡ Internships/placements/co-op programs

   ➡ Employer-led competency frameworks

Current Status of This Vision

➡ Background preparation

➡ Employer-Academia Workshop, October 2020

➡ Kicked off NSF IUSE ICT Grant, June 2021

➡ Launched CS202X Task Force, May 2021

➡ Challenges and opportunities

➡ Inertia to change

➡ Employer-academia relationships

➡ Barriers to real-world experiences

➡ Teaching and assessing competencies

➡ Needs of a diverse workforce

➡ Rapid developments in the credential space

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