Establishing Computing Curricula: An Evolving Professional Endeavor

John Impagliazzo, Ph.D.

2017 July 3

Outline

Phase 1:
Computing Curricular History

Phase 2:
Computer Engineering Curriculum (CE2016)

Phase 3:
Information Technology Curriculum (IT2017)

Phase 4:
Computing Curricular Overview (CC2020)

Phase 5:
General Questions

Computing Curricula History (1)

ACM Two-Year (Technical) College "Mini" Reports
Data Processing (ca. 1962)

ACM Curriculum '68
Landmark, Turing Award, Mix of Math and Computing (1968)

Information Systems Report
Independent, Dan Cougar (1973)

ACM Recommendations and Guidelines for Associate-Degree Programs in Computer Programming
ACM Produced (1975)

Computing Curricula History (2)

ACM Curriculum ’78

Real Birth of Computer Science, Promoted Early Programming (1978)

ACM Curriculum Modifications

Programming First, CS1, CS2, CS3, *Discrete Structures* (1983-1984)

ACM Information Systems Report

First Organizational IS report (1983)

Program in Computer Science and Engineering

IEEE Computer Society (Cain, Langdon, Varanasi)

“Birth” of Computer Engineering as a Discipline (1984)

Computing Curricula History (3)

DPMA(AITP) '90 Information Systems Curriculum

Information Systems (1990)

ACM/IEEE Curriculum '91

First Joint Organizational Report (1991)

Spurred by the Denning 1987 Paper "Computing as a Discipline"

Introduced Knowledge Areas and Knowledge Units

Abandoned Courses, Tried to be "One Size Fits All"

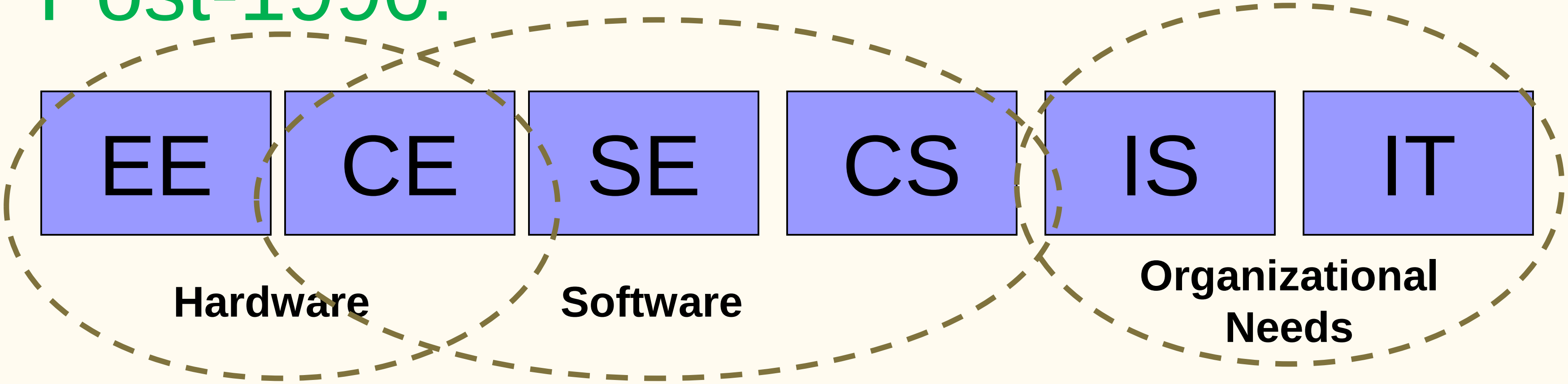
Arranged to Produce Thousands of Possible Curricula

Publishers Balked at the Recommendations – What Books to Publish?

Computing Curricula History (4)

Pre-1990:

Post-1990:



Computing Curricula History (5)

ACM Reports on Associate-Degree Programs

Four Reports: CS, IS, CET, CSS, Other Disciplines (1993)

Very Popular, All Printed Copies Sold Out

ACM/AIS/DPMA(AITP) IS Curriculum '97

A 'Tour de Force' Information Systems Curriculum (1997)

Known and Used Worldwide

ACM/AIS/DPMA(AITP) IS Curriculum 2002 (IS2002)

Update of IS'97 (1997)

ACM Reports for Associate-Degree Programs

Curricula Updates (1995-2002)

Computing Curricula History (6)

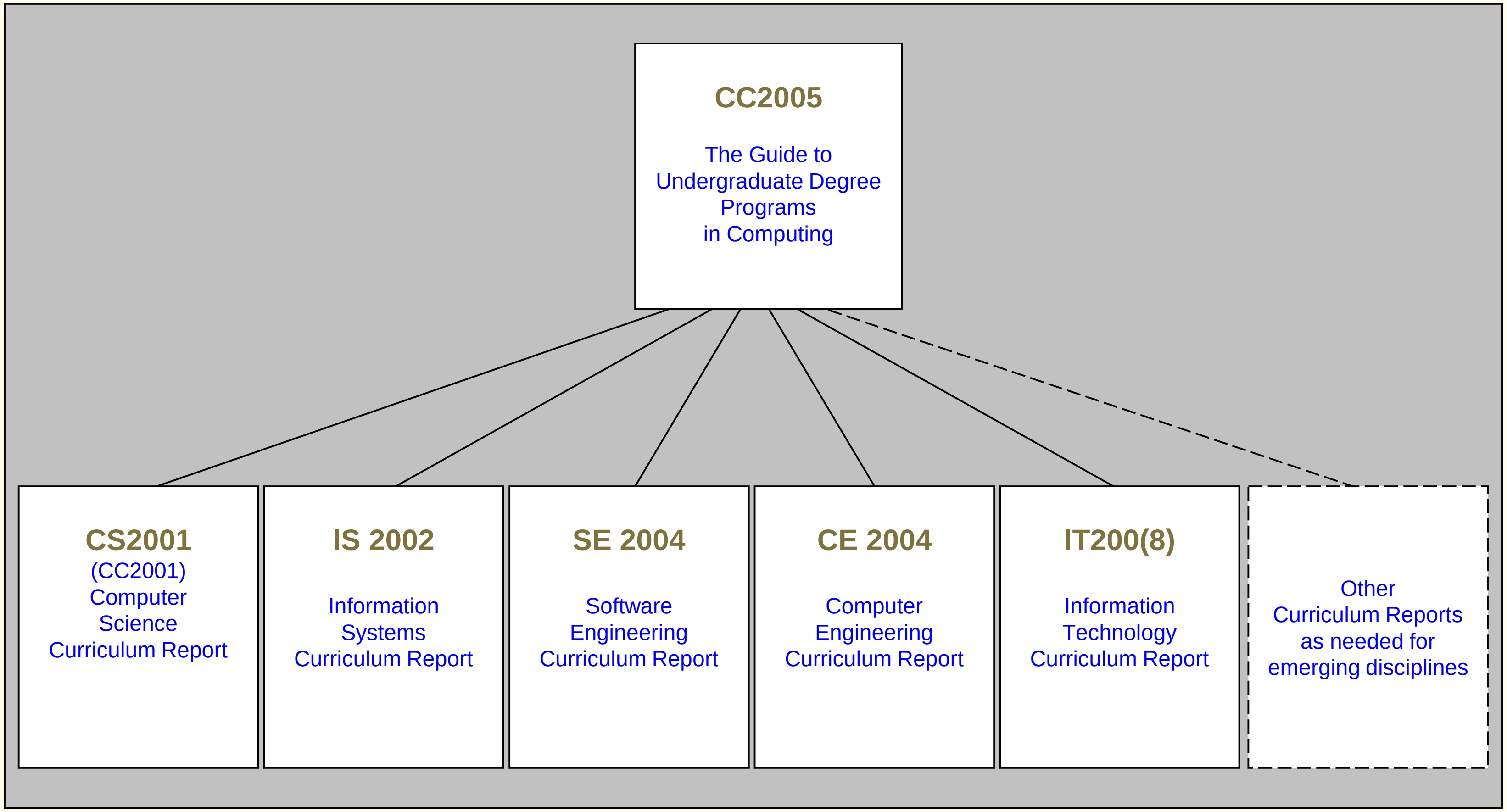
ACM/IEEE Computing Curriculum (CC/CS2001)
Really Computer Science (2001)

ACM/IEEE Software Engineering Curriculum (SE2004)
First of SWE Curriculum Report in the Field (2004)

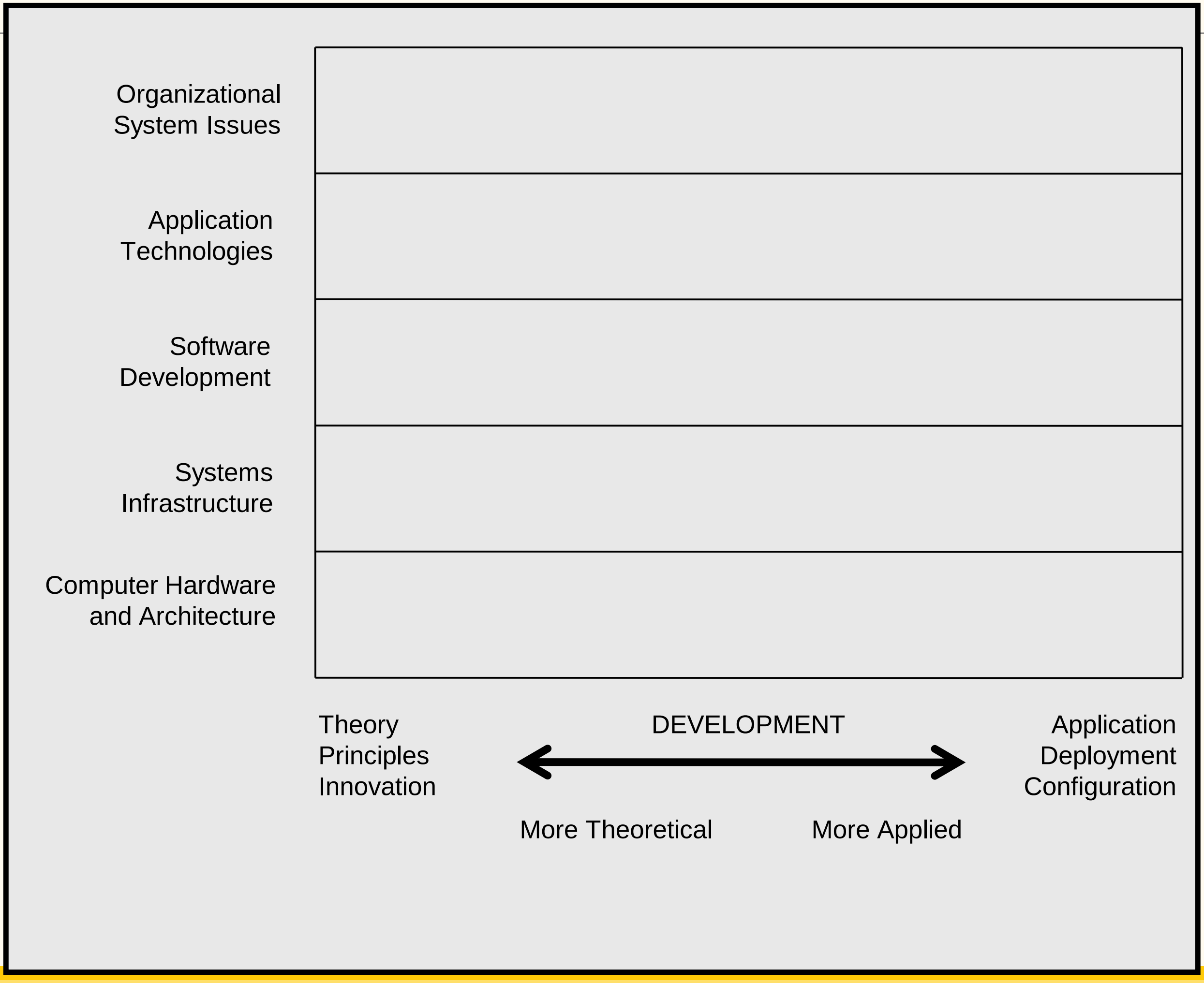
ACM/IEEE Computer Engineering Curriculum (CE2004)
True CE-focused Report (2004)
Not Based on the 1984 Model

ACM/IEEE/AIS/Etc. Overview Report (CC2005)
First of its Kind (2005)

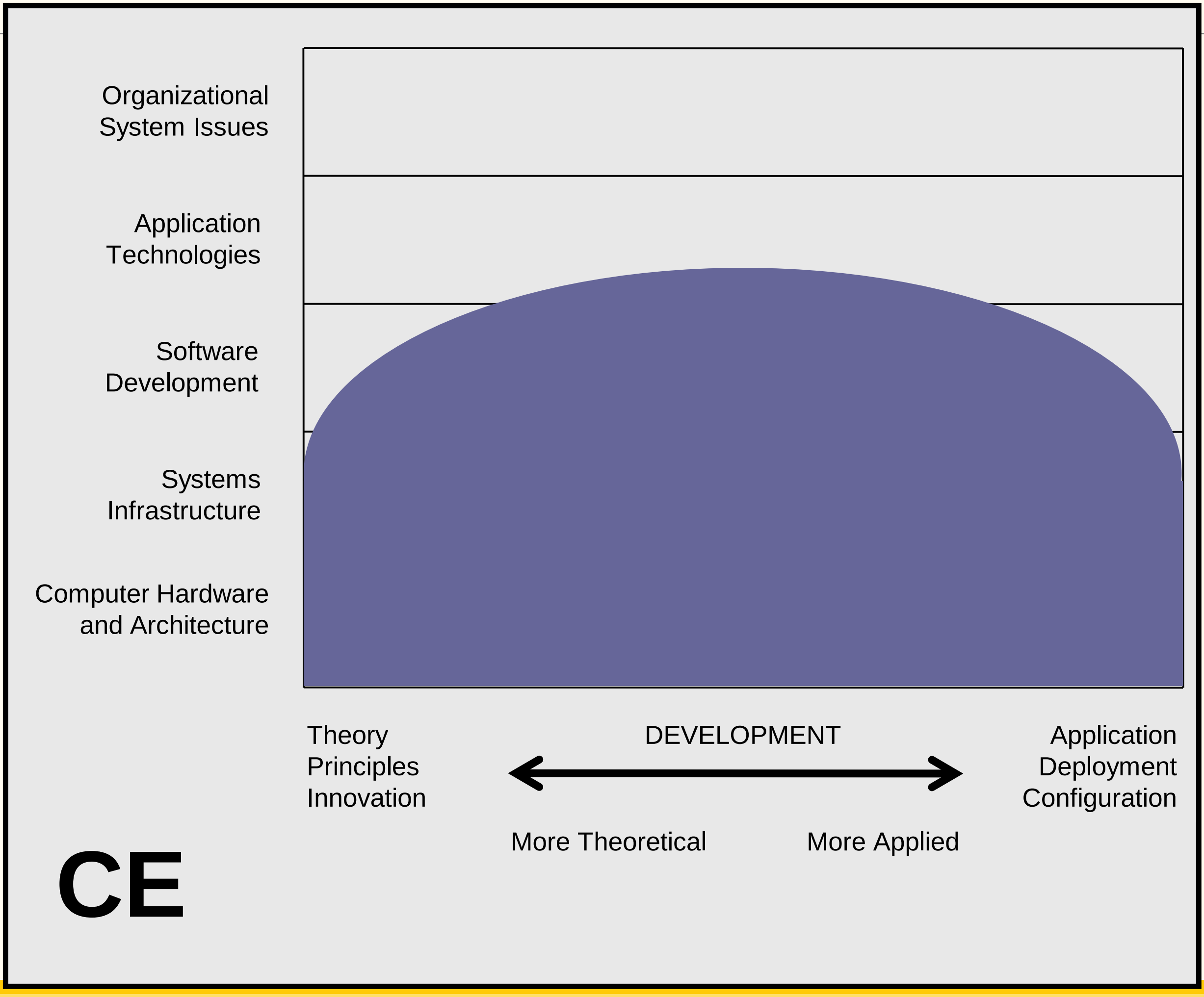
Computing Curricula History (7)
Structural Organization (ca. 2005)



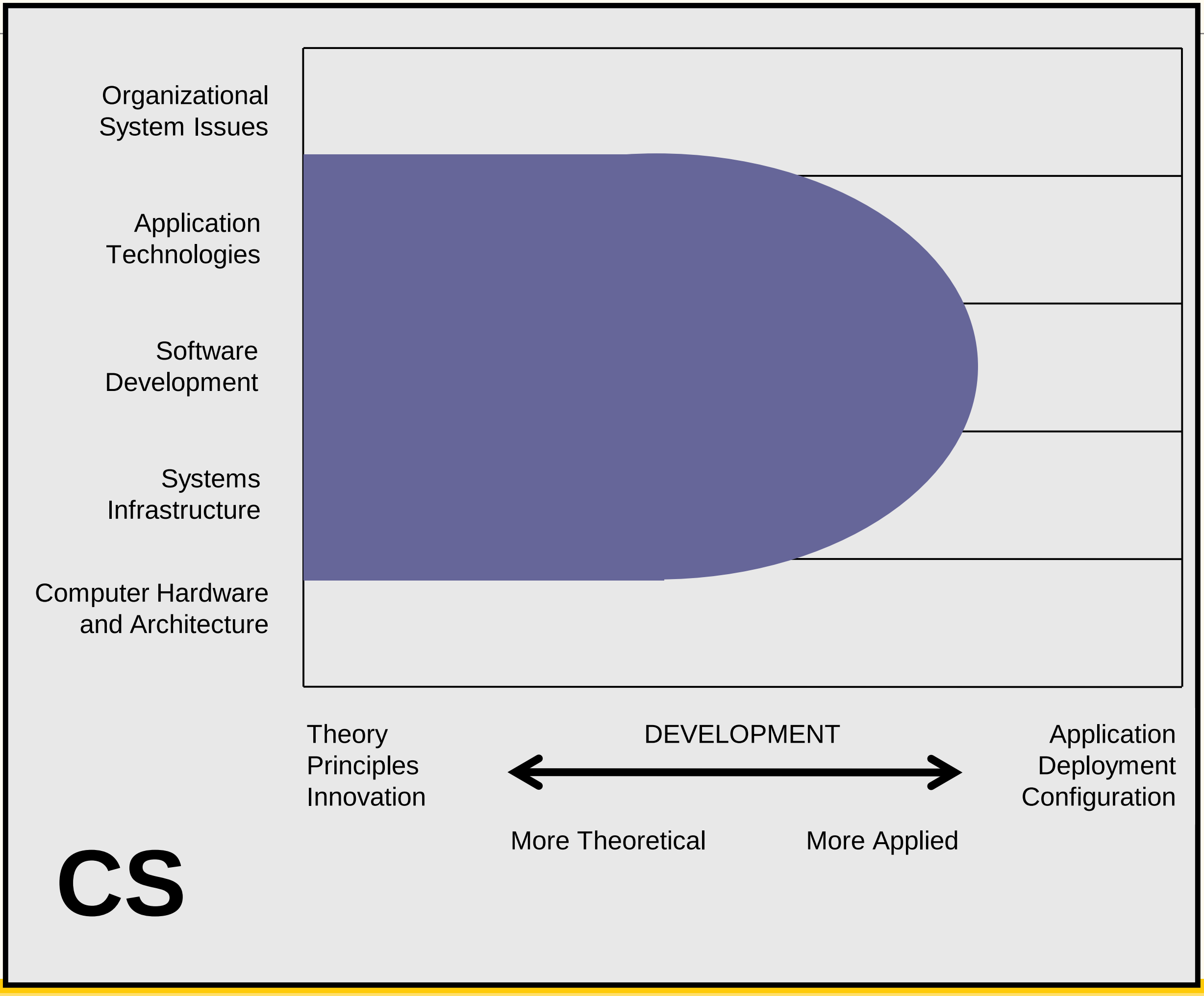
Computing Visualized



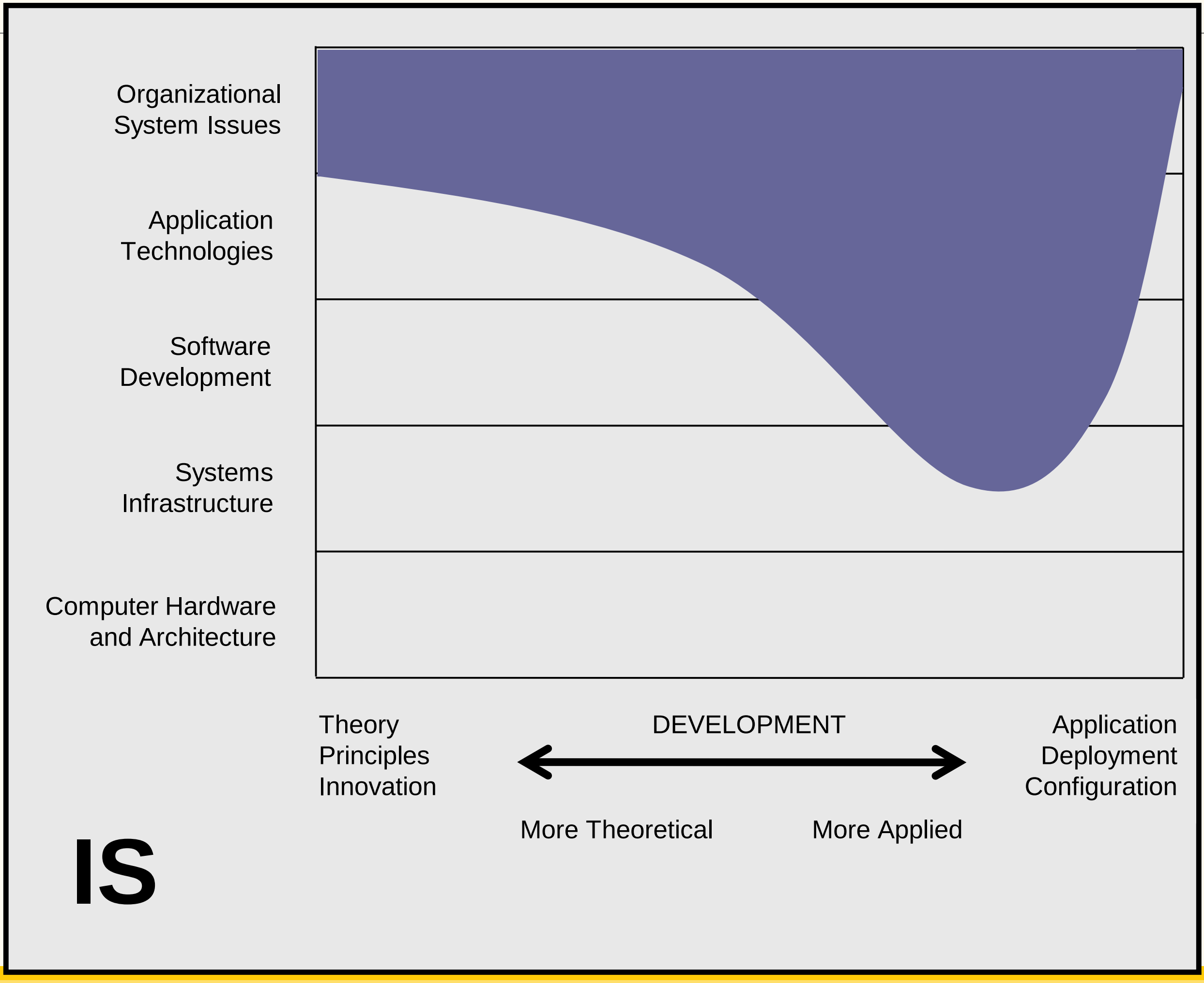
Computer Engineering Visual



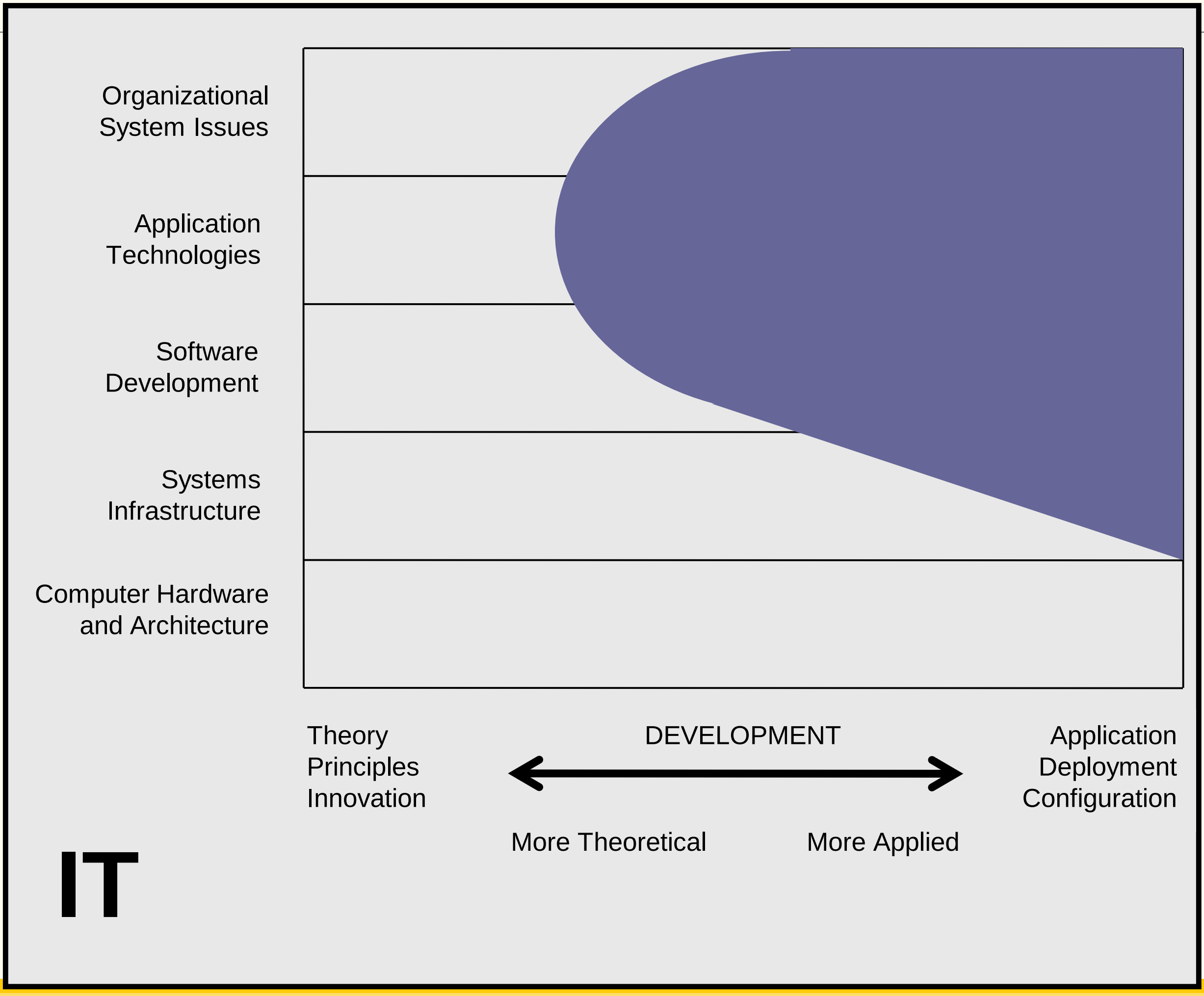
Computer Science Visual



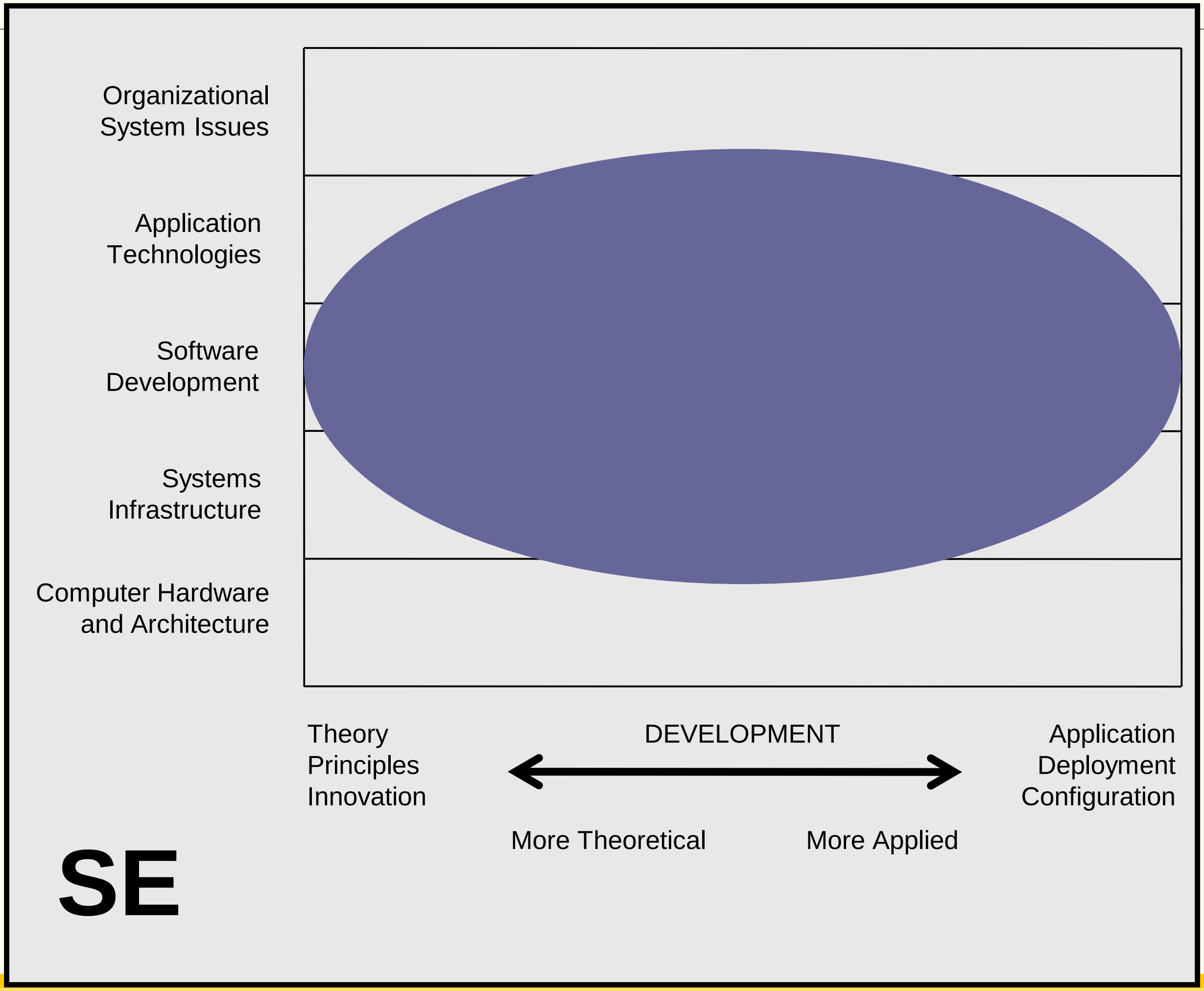
Information Systems Visual



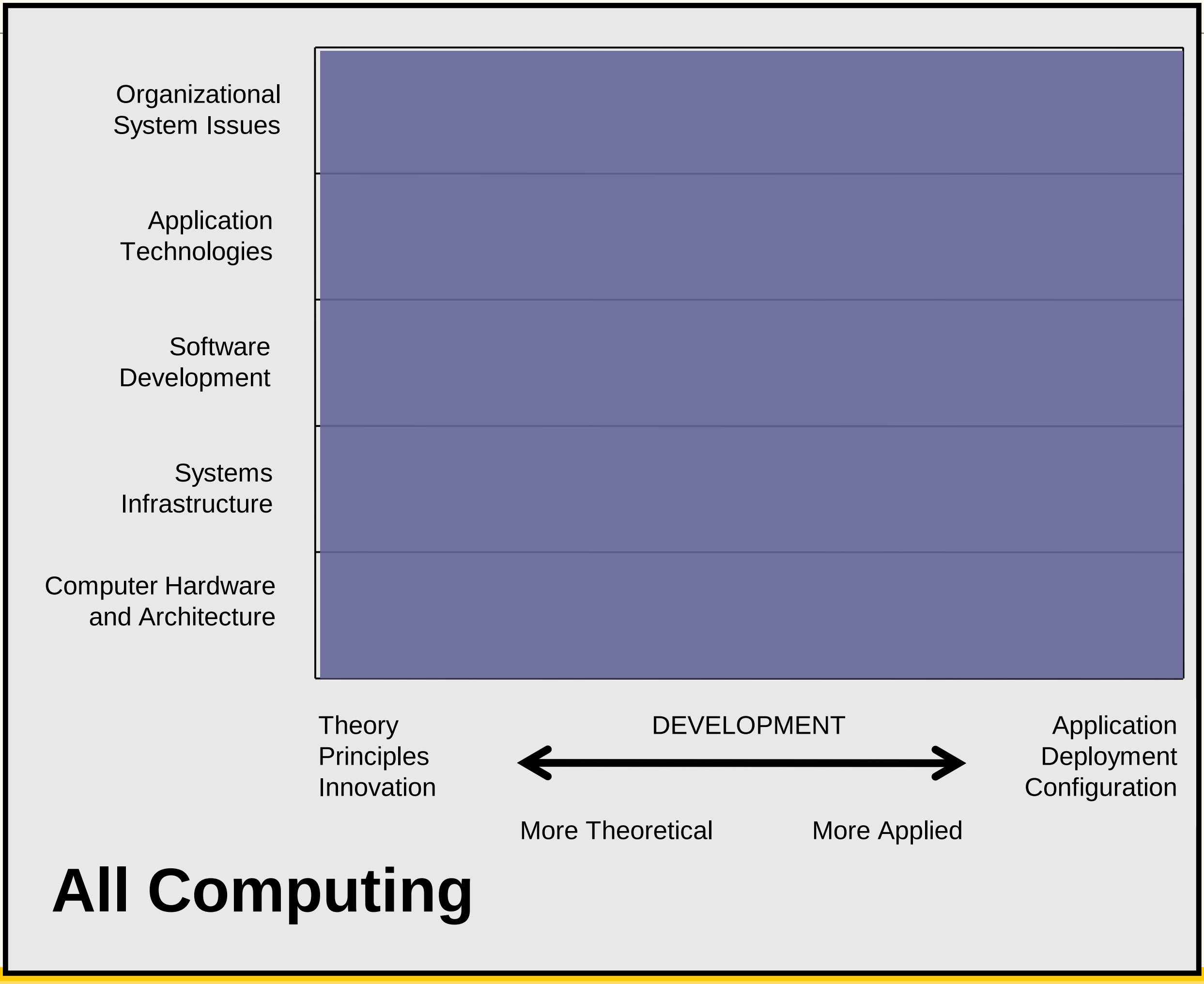
Information Technology Visual



Software Engineering Visual



Computing Visualized



Computing Curricula History (8)

ACM/AIS Master's Information Systems Curriculum (IS2006)
First of its Kind (2006)

ACM Computer Science Curriculum Report (CS2008)
Minor Update of CS2001 (2008)

ACM/IEEE Information Technology Report (IT2008)
First of its Kind (2008)

ACM/AIS Information Systems Curriculum (IS2010)
Update of Earlier Undergraduate Curriculum (2010)

Computing Curricula History (9)

ACM/IEEE Computer Science Curriculum (CS2013)

Update of CS2001/CS2008 Reports (2013)
Used a Two-Tier Core of “Musts” and “Shoulds”
Many Exemplars of Existing Programs

ACM/IEEE Software Engineering Curriculum (SE2014)

Update of SE2004 (2014)
Some Improvement over SE2004

ACM Two-Year College Information Technology Curriculum

Update from 2001 Document (2014)
Very Avant Gard; Learning Outcomes Only
No Course Identified

Computing Curricula History (10)

ACM/IEEE Computer Engineering Curriculum (CE2016)

Moderate Update of CE2004 Curriculum (2016)
Balanced Approach to Curriculum Reform
Excludes Topics

ACM/AIS Information Systems Curriculum (IS2016)

Update of Earlier 2006 Undergraduate Curriculum (2016)

ACM/IEEE Information Technology Curriculum (IT2017)

Update of Earlier 2008 Undergraduate Curriculum (2017)
Representatives from Five Countries, Four Continents
Based on competencies
Driven by industry, 25% representation
Focus on *performance*, not knowledge

Computing Curricula *Future*

ACM/IEEE/AIS Cybersecurity Curriculum
Planned for 2018 (??)

ACM/AmStatSociety/IEEE Data Science Curriculum
Planned for 2019 (??)

ACM/IEEE/Computing Curricula 2020
Update of CC2005 (2020)

????????
(2020s)

Alguma pergunta?

ACM/IEEE
Computer Engineering Curricular Guidelines

[CE2016]

An Update to CE2004

CE2016 Team

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IBM Research

* Member of CE2004 Team

CE2016 Report Structure

Contents

- Introduction
- Computer Engineering as a Discipline
- Computer Engineering Body of Knowledge
- Engineering Practice and the CE curriculum
- Professional Practice
- Curriculum Implementation Issues
- Institutional Adaptation

Appendices

- CE Body of Knowledge
- CE Sample Curricula
- CE Laboratories

CE2016 – Body of Knowledge

Knowledge Areas

CE-CAE Circuits and Electronics

CE-CAL Computing Algorithms

CE-DIG Digital Design

CE-NWK Computer Networks

CE-SEC Information Security

CE-SGP Signal Processing

CE-SWD Software Design

Knowledge Areas

CE-CAO Computer Arch. and Organization

CE-CSE Computing Systems Engineering

CE-ESY Embedded Systems

CE-PFP Professional Practice

CE-SET Strategies for Emerging Technologies

CE-SRM Systems Resource Management

New Content

- System on Chip (SoC) instead of VLSI
- Field Programmable Gate Array (FPGA) instead of Application Specific Integrated Circuit (ASIC)
- Multicore beyond parallel
- Security, particularly for networked and embedded devices, is now its own KA
- Mobile and other power-aware systems
- Software: object-oriented design, modern development processes (e.g., agile), refactoring
- Requirements, verification, validation for systems (encompasses hardware and software)
- Tools for hardware and software development and design
- Emerging technologies

CE KAs, Math, and Core Hours

		Core Hours	Totals
CE-CAE	Circuits and Electronics	50	
CE-CAO	Computer Architecture and Organization	60	
CE-CAL	Computing Algorithms	30	
CE-CSE	Computing Systems Engineering	30	
CE-DIG	Digital Design	50	
CE-ESY	Embedded Systems	40	
CE-NWK	Computer Networks	20	
CE-PFP	Professional Practice	20	
CE-SEC	Information Security	20	
CE-SET	Strategies for Emerging Technologies	10	
CE-SGP	Signal Processing	30	
CE-SRM	Systems Resource Management	20	
CE-SWD	Software Design	40	***420***
CE-CAN	Analysis of Continuous Functions	30	
CE-DSC	Discrete Structures	30	
CE-LAL	Linear Algebra	20	
CE-PRS	Probability and Statistics	30	***110***
			530

ESY Knowledge Units

CE-ESY-1 History and overview [1]

CE-ESY-2 Relevant tools, standards, and/or engineering constraints [2]

CE-ESY-3 Characteristics of embedded systems [2]

CE-ESY-4 Basic software techniques for embedded applications [3]

CE-ESY-5 Parallel input and output [3]

CE-ESY-6 Asynchronous and synchronous serial communication [6]

CE-ESY-7 Periodic interrupts, waveform generation, time measurement [3]

CE-ESY-8 Data acquisition, control, sensors, actuators [4]

CE-ESY-9 Implementation strategies for complex embedded systems [7]

CE-ESY-10 Techniques for low-power operation [3]

CE-ESY-11 Mobile and networked embedded systems [3]

CE-ESY-12 Advanced I/O topics [3]

CE-ESY-13 Computing platforms for embedded systems

CE-ESY-14 Tradeoffs in embedded systems

ESY Knowledge Units

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CE-ESY-11 Mobile and networked embedded systems [3]

CE-ESY-12 Advanced I/O topics [3]

CE-ESY-13 Computing platforms for embedded systems

CE-ESY-14 Tradeoffs in embedded systems

KU Example: ESY-5

ESY-5 Parallel input and output
Minimum core coverage time: 3 hours

Core Learning Outcomes:

- Describe the appropriateness of different I/O configurations (input, strong drive, weak pullup/pulldown, open-drain, tri-state) available in general purpose I/O (GPIO) for a given target application.
- Create programs that perform a sequence of input/output operations on one more GPIOs using a polled approach.
- Describe how interrupts are supported on the target embedded system(s).
- Create programs that perform a sequence of input/output operations on one more GPIOs using an interrupt-driven approach.
- Discuss mechanisms such as hardware and software FIFOs for buffering data streams.

Supplemental Learning Outcomes:

- Discuss Direct Memory Access (DMA) and describe how it is supported on the target embedded system.
- Create programs that perform a sequence of input/output operations using DMA.

CE Laboratories

Types of Computer Engineering Laboratories
(Table 4.1)

Laboratory Type	Must	Should	Supplemental
Circuits and Electronics	●●●●		
Computer Architecture Design			●
Digital Signal Processing			●
Digital Logic and System Design	●●●●		
Embedded Systems	●●●●		
Introduction to Engineering			●
Networking		●●	
Software Design		●●	
Senior Project Design	●●●●		

Embedded Systems Laboratory

Typical Description: Experiments involving interfacing memory and peripheral devices to a microcomputer; design of software to control peripheral devices; integration of computer hardware and software for system control.

Typical Configuration:

- microcontroller development board/kit
- computer for hosting software tools
- integrated development environment for the selected microcontroller
- libraries of software modules to support selected peripheral devices
- powered breadboard for interfacing peripheral devices to the microcontroller
- oscilloscope
- logic analyzer
- multimeter
- triple output DC power supply

Vendors for this equipment in 2016 include ST Microelectronics, Digilent, Keil, Agilent, and others.

Typical Offering: Lower level; one two-hour laboratory experience per week.

Where to find CE2016?

Go to:

www.acm.org

Then click on:

Education

Then click on:

Curricula Recommendations

Then scroll to:

Computer Engineering
CE2016

Alguma pergunta?

ACM/IEEE
Information Technology Curricular Guidelines

[IT2017]

An Update to IT2008

IT2017 Team

Executive Committee

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Mount Royal University, Canada

Svetlana Peltsverger
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Vrije Universiteit, Netherlands

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VioTech Solutions , USA

IT2017 Report Structure

Contents

Introduction
The Information Technology Discipline
Preparing Contemporary IT Professionals
Competencies and Information Technology
Industry Perspectives on Information Technology
Information Technology Curricular Framework
Implementing the IT Curricular Framework
Institutional Adaptations

Appendices

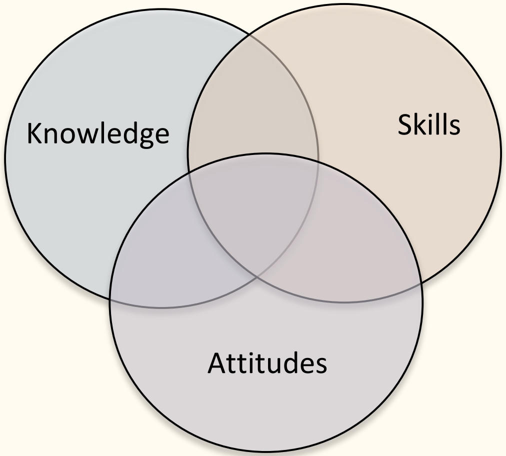
Enterprise IT Skills Framework
Performances
Traditional Four-year IT Curricula Examples
Information Technology in Other Contexts

Competency Based

Competency in Words

The term competence refers to the performance standards associated with a profession or membership to a licensing organization.

Competency as an Image



Industry Driven (2016 Data)

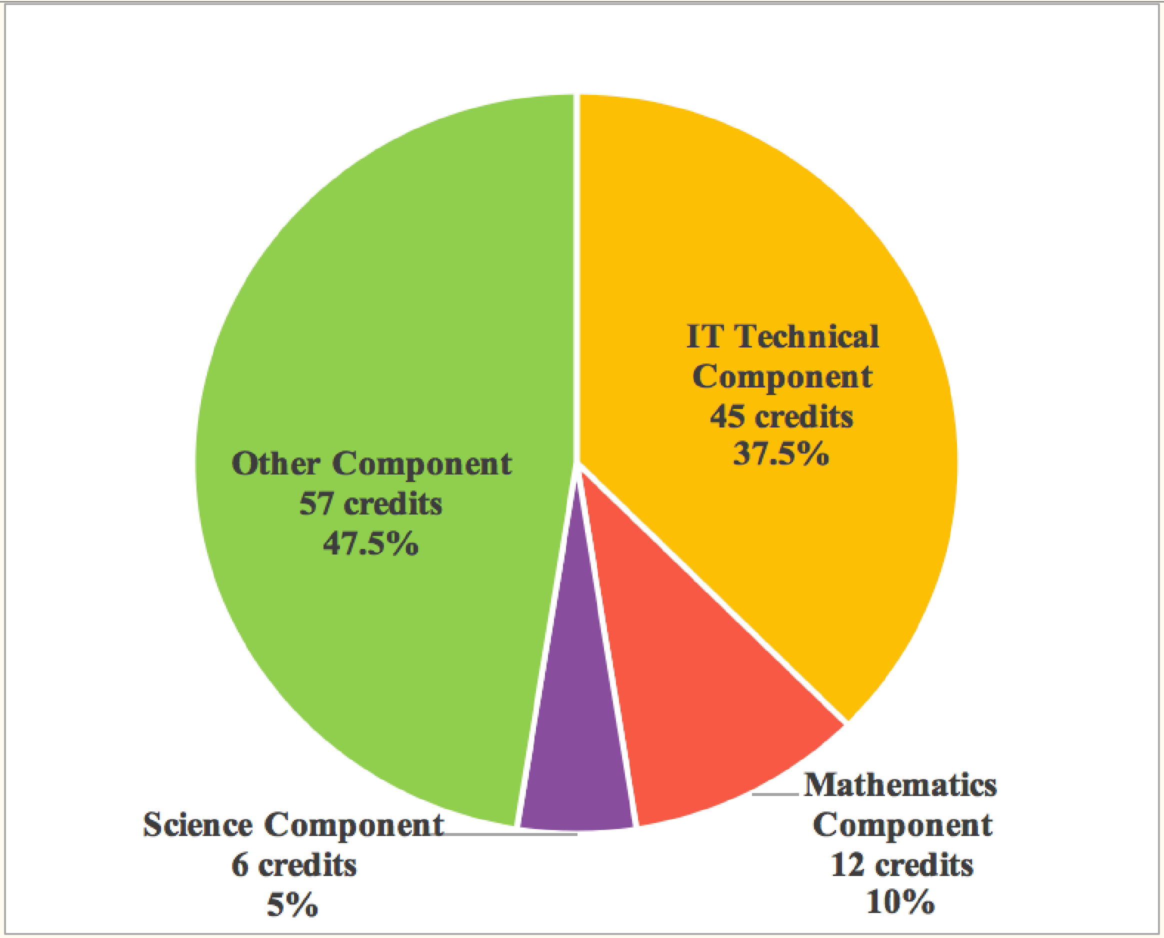
Technical Skills	Needed at Company
Security	40%
Database/Information management	38%
PC support	36%
Storage/Backup	33%
Networks	31%
Cloud architecture	29%
Telecommunications	27%
Web development	27%
Server/Datacenter management	27%
Mobile device support	24%
Application development	23%
Big Data tools/analytics	23%
Virtualization	21%

Business Skills/Soft Skills	Needed at Company
Flexibility	41%
Analytical skills	39%
Teamwork	37%
Customer service	34%
Innovation/Problem solving	33%
Project management	30%
Strong work ethic	29%
Motivation	28%
Business understanding	27%
Broad technology knowledge	27%
Verbal/written communication	22%

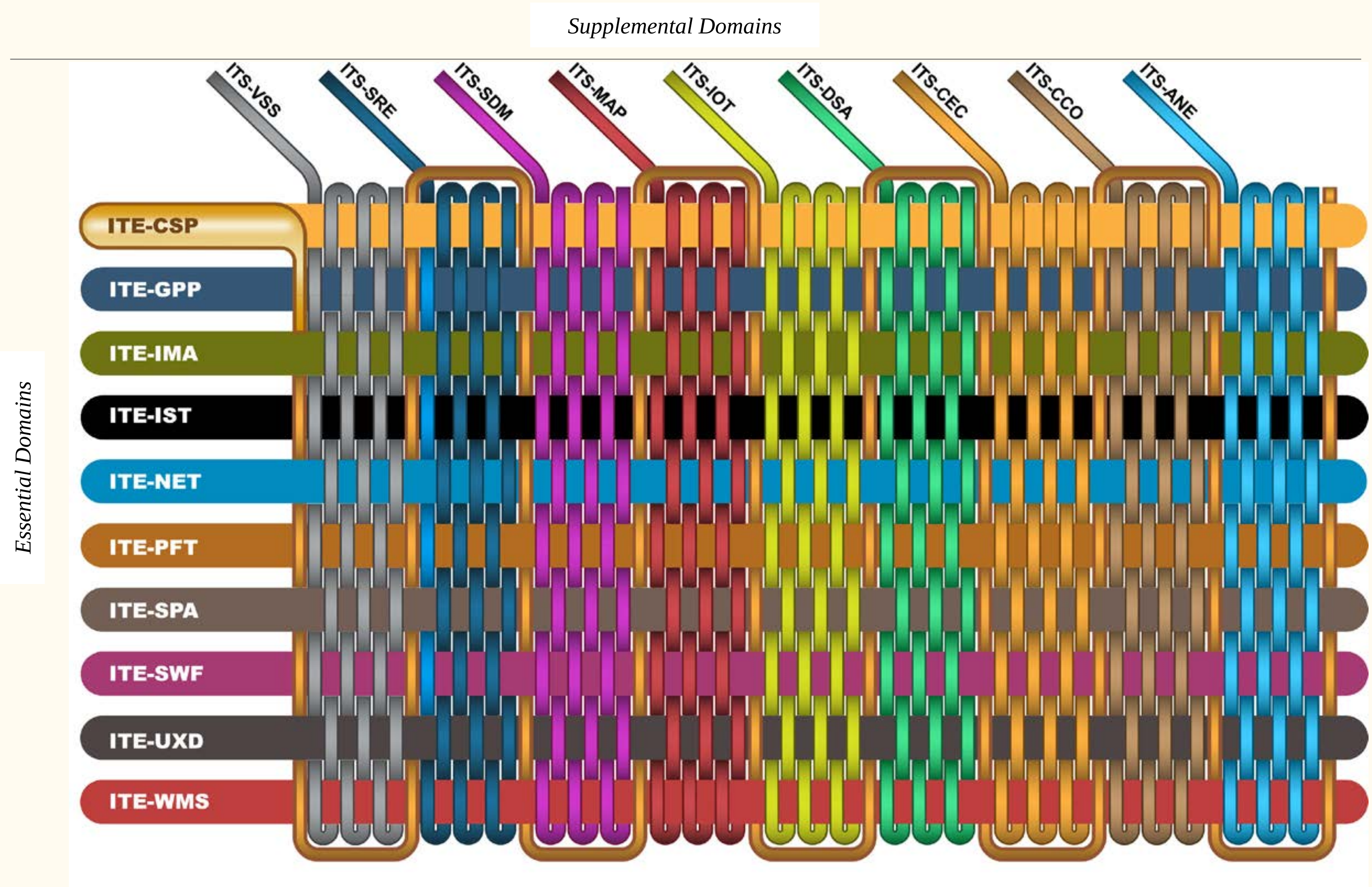
IT2017 Curricular Framework (1)

IT Domains	Essential Percentage	Supplemental Percentage
Essential Only		
Information Management	6%	0
Integrated Systems Technology	3%	0
Platform Technologies	1%	0
System Paradigms	6%	0
User Experience Design	3%	0
Subtotal:	**19%**	**0**
Essential + Supplemental		
Cybersecurity Principles / Cybersecurity Emerging Challenges	6%	4%
Global Professional Practice / Social Responsibility	3%	2%
Networking / Applied Networks	5%	4%
Software Fundamentals / Software Development and Management	4%	2%
Web and Mobile Systems / Mobile Applications	3%	3%
Subtotal:	**21%**	
Supplemental Only		
Cloud Computing	0	4%
Data Scalability and Analytics	0	4%
Internet of Things	0	4%
Virtual Systems and Services	0	4%
Subtotal:	**0**	
IT2017 TOTAL:	**40.0%**	

IT2017 Curricular Framework (2)



IT2017 Curricular Framework (3)



Where to find IT2017?

Go to:

it2017.acm.org

Status:

Temporary working website

Final version available 2017 November

Alguma pergunta?

ACM/IEEE

Computing Curricula Overview Report

[CC2020]

An Update to CC2005

CC2020 Project

Activities

- Consolidation of all computing curricular guidelines
- Modern update of CC2005
- Avant-garde document for the future of computing education

Operational Structure

- Supported primarily by ACM and IEEE Computer Society
- Task Force (currently 30 representatives)
- Currently all global regions represented
  - 14 countries
  - 6 continents
- Steering committee (up to 15 reps) subset of task force
- Industry Perspectives on Information Technology

Outcome

- “Stay tuned”

Obrigado!

Questões gerais?