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Continuing education curricula and competency matching in the area of Digital Transformation (DX): Cases of Smart SE, SFIA, and CC2020

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WASEDA University



<https://www.waseda.jp/culture/news/2020/04/30/10381/>

Prof. Dr. Hironori Washizaki



- Waseda University in Tokyo
 - Professor and the Associate Dean of the Research Promotion Division
 - **Leading Smart SE: Lifelong education of IoT/AI/DX**
 - Leading projects on STEM education
- Academia and industry
 - National Institute of Informatics, Visiting Professor
 - SYSTEM INFORMATION and eXmotion, Outside Directors
- Professional communities
 - IEEE Computer Society, 1st Vice President
 - IEEE Transactions on Emerging Topics in Computing, Associate Editor
 - MDPI Education Sciences, Editorial Board Member
 - ISO/IEC/JTC1 SC7/WG20, Convener
 - IEEE Conference on Software Engineering Education and Training (CSEE&T), Steering Committee Member
 - IEEE COMPSAC, Advisory Committee Member
 - Asia-Pacific Software Engineering Conference (APSEC), Steering Committee Member

1. Smart SE in the era of DX and 60-year curriculum
2. Practical features in Smart SE
3. Curriculum evaluation based on SFIA Framework
4. Comparison between Industry and University:
SFIA Framework and CC2020

- Overall activity of using digital technologies to renew the value proposition to customers and to transform the related business and operations [Barman12] [Jonathan20].
- Transformation of business models to create customer-driven values through data and digital technologies [Washizaki20]
- Professionals who lead DX by using digital technologies are expected.

S. J. Berman, "Digital transformation: opportunities to create new business models," *Strategy & Leadership*, vol. 40, pp. 16–24, 2012.

G. M. Jonathan et al., "Business-it alignment in the era of digital transformation: Quo vadis?" in *53rd Hawaii International Conference on System Sciences, HICSS 2020*. ScholarSpace, 2020, pp. 1–10.

H. Washizaki et al., "Framework and value-driven process of software engineering for business and society (SE4BS)," in *9th International Congress on Advanced Applied Informatics, IIAI-AAI*. IEEE, 2020, pp.701–706.

60-year curriculum: New perspective on continuing education

- Concept proposed by Gary Matlin (University of California, Irvine), John Richards and Chris Dede (Harvard Graduate School of Education)
- Centered on six decades of employment
- Requiring a lifetime of learning in the context of repeated occupational change and transition
- Features of 60-years curriculum in global network
 - Consulting and entrepreneurship
 - Digitalization
 - Transferable skills
 - Agile network



Smart SE : Smart Systems and Services innovative professional Education program

<https://www.waseda.jp/inst/smartse/en>

■ Head: Waseda University

■ Partner universities including:

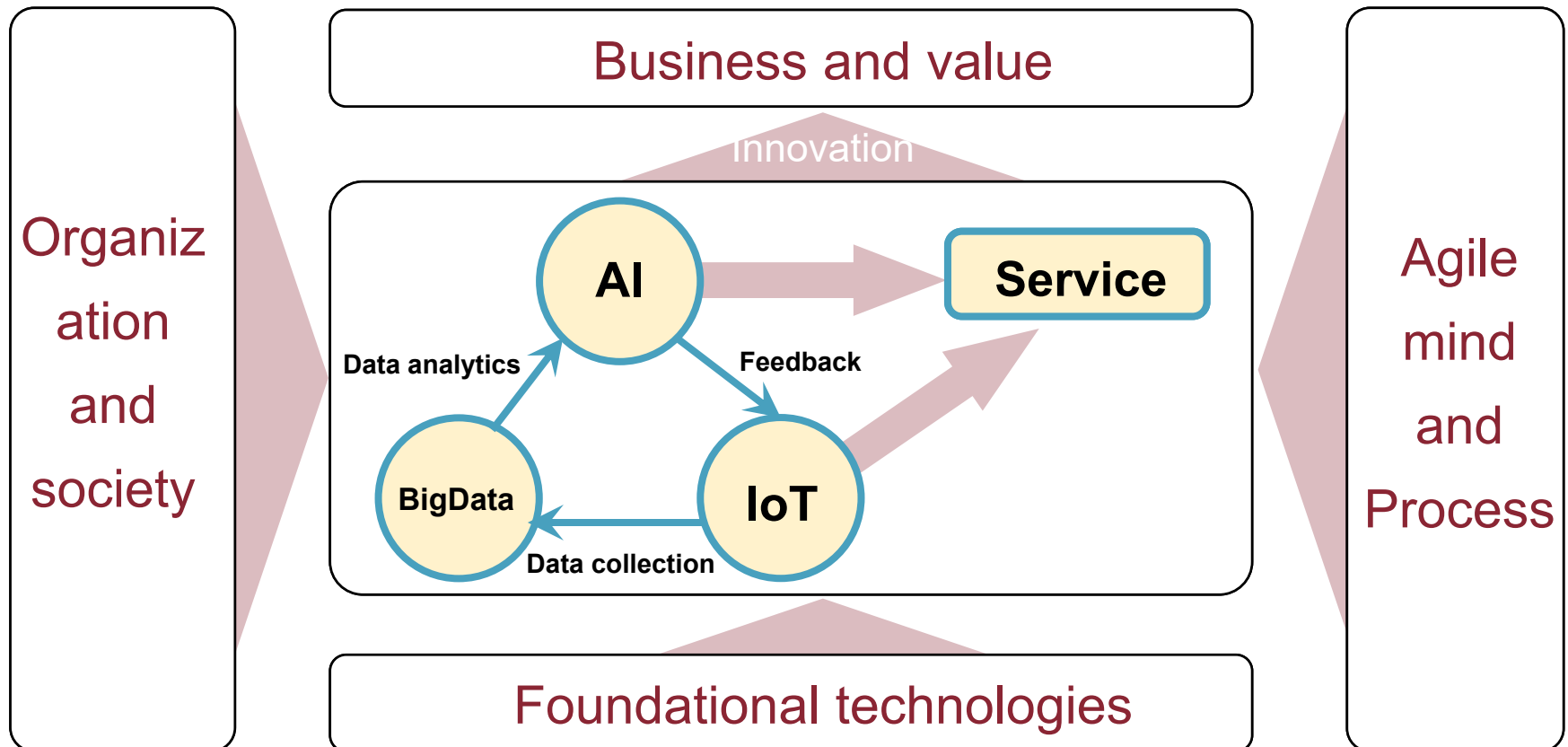
Ibaraki University; Gunma University; Tokyo Gakugei University; Tokyo Institute of Informatics; Osaka University; Kyushu University; Japan Advanced Institute of Science and Technology; Nara Advanced Institute of Science and Technology; Tokyo University of Technology; Toyo University; Tsurumi University; National Institute of Informatics

■ 21 Partner companies and organizations (at the time of enPiT-Pro program)

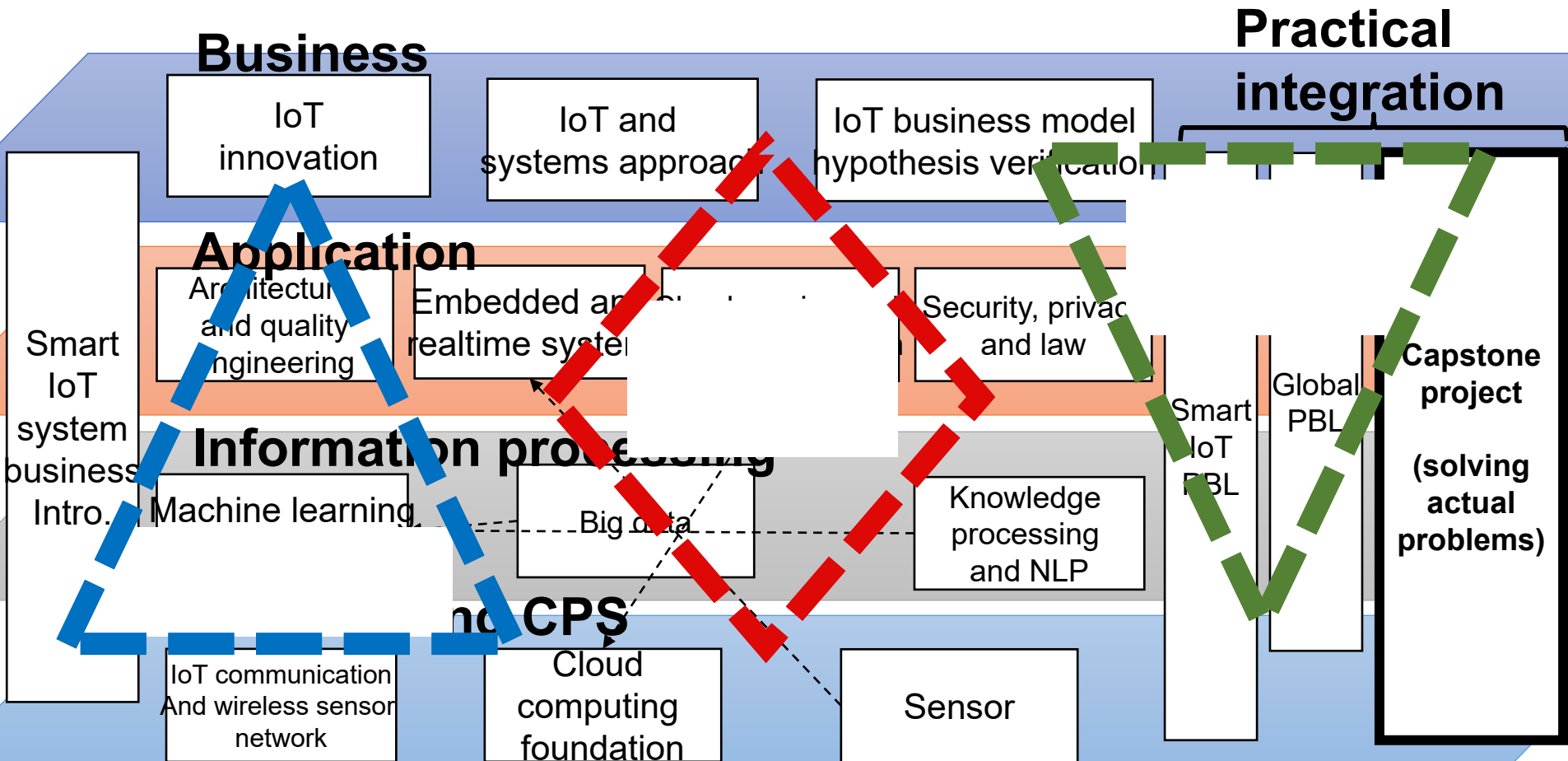
Toshiba; Fujitsu; NEC; Hitachi; e-Seikatsu; Yahoo; Whole Brain Architecture Initiative; Denso; Halex; Medical Information Company for Innovation; System Information; Mobile Computing Promotion Consortium; Japan Association of New Economy; Information Technology Federation of Japan; IT Verification Industry Association; Japan Society of Next Generation Sensor Technology; Japan Electronics and Information Technology Industries Association; Japan Embedded Systems Technology Association; Computer Software Association of Japan; Advanced IT Consortium to Evaluate, Apply and Drive; Weather Business Consortium

Smart SE: Recurrent Education Program of IoT and AI for Business in the era of DX

- **Consulting and entrepreneurship:** Business and value
- **Digitalization:** AI, IoT and other advanced digital technologies
- **Transferable skills:** Agile mind, capston projects (continuous collaboration)
- **Agile network:** Networking, nation-wide industry-academia collaboration



Curriculum over different layers in digital transformation (DX) era



Industry-academia collaboration network (at the time of enPiT-Pro)

Using the nation-wide network

- Developed teaching materials will be made available for use in each region, and will be used to train working adults
- Further expand the university network during the grant period (Ritsumeikan University, etc.)

Kitakyushu region

- Already established the Kitakyushu consortium with companies in the electronics industry
- Already running a working adult re-education program through a consortium with Waseda University (implemented ahead of enPiT-Pro efforts)
- Promoting education, graduate school enrollment, and collaborative research to regional companies that are part of the consortium

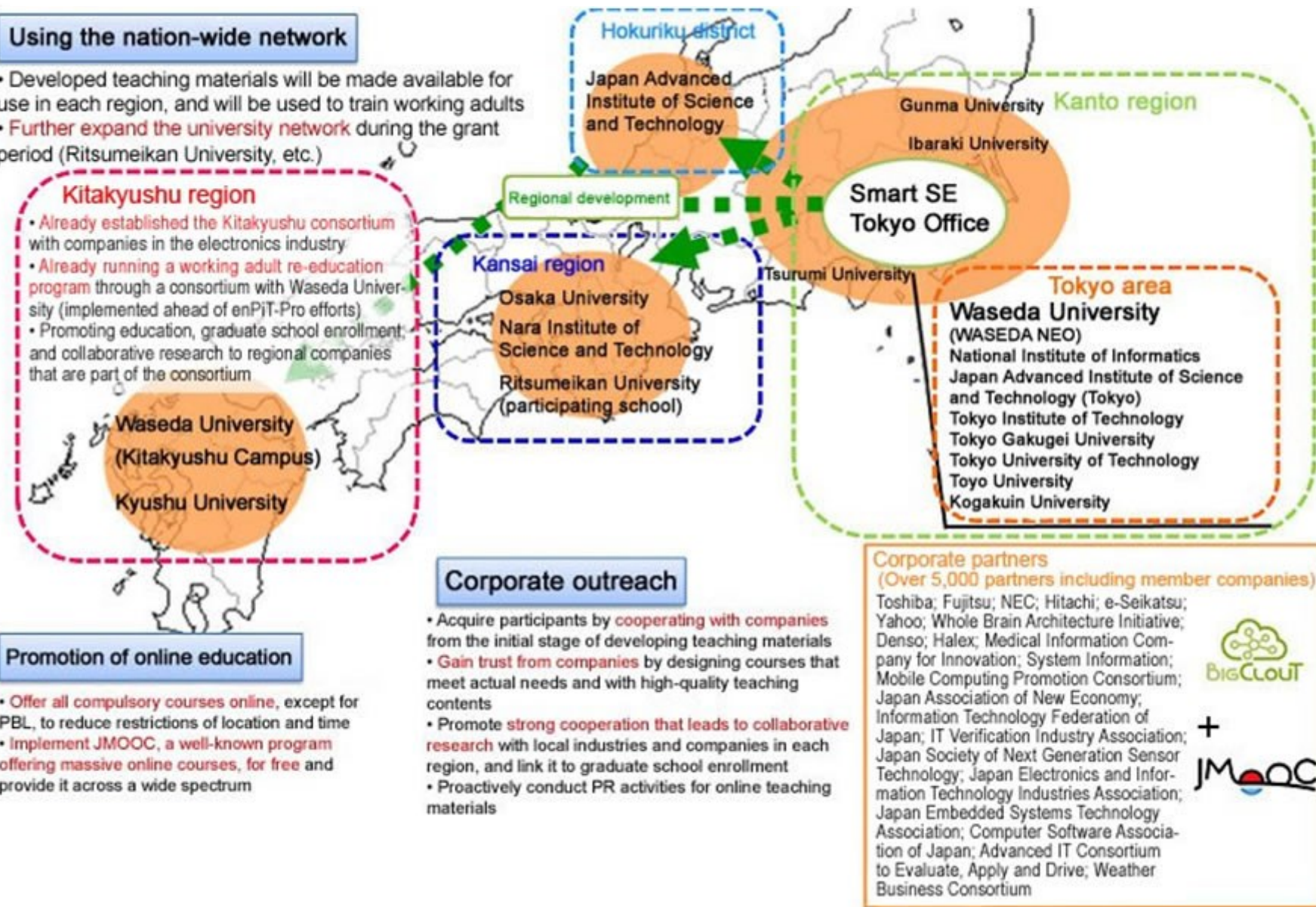
Waseda University
(Kitakyushu Campus)
Kyushu University

Promotion of online education

- Offer all compulsory courses online, except for PBL, to reduce restrictions of location and time
- Implement JMOOC, a well-known program offering massive online courses, for free and provide it across a wide spectrum

Corporate outreach

- Acquire participants by cooperating with companies from the initial stage of developing teaching materials
- Gain trust from companies by designing courses that meet actual needs and with high-quality teaching contents
- Promote strong cooperation that leads to collaborative research with local industries and companies in each region, and link it to graduate school enrollment
- Proactively conduct PR activities for online teaching materials



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1. Comprehensive program sets and blended learning
 - MOOC and on-demand lectures
 - Project-based learning (PBL)
2. Quality assurance in education
 - Course evaluation and interview
3. Feedback loop of education and research
 - Individual subject (e.g., integrated modeling method)
 - Automated review of entire program

1. Blended learning

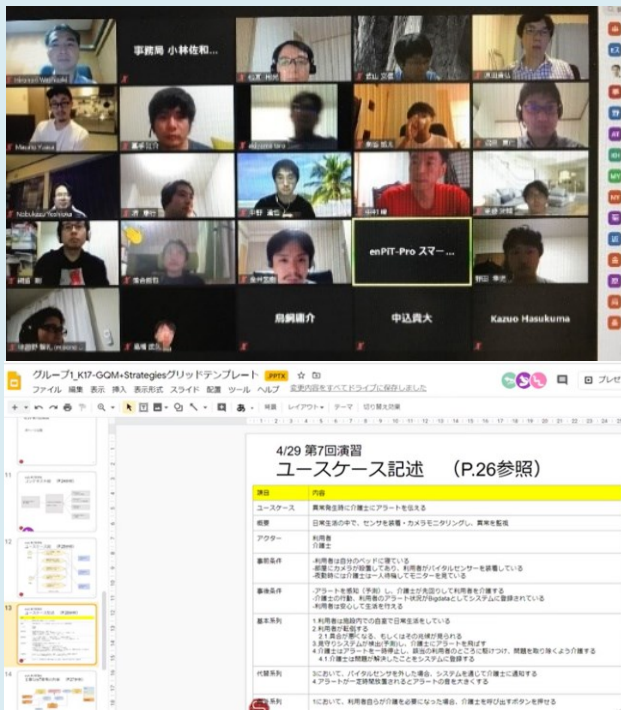
Remote lecture and class-room solo and team exercise (practice)

ONLINE

REAL

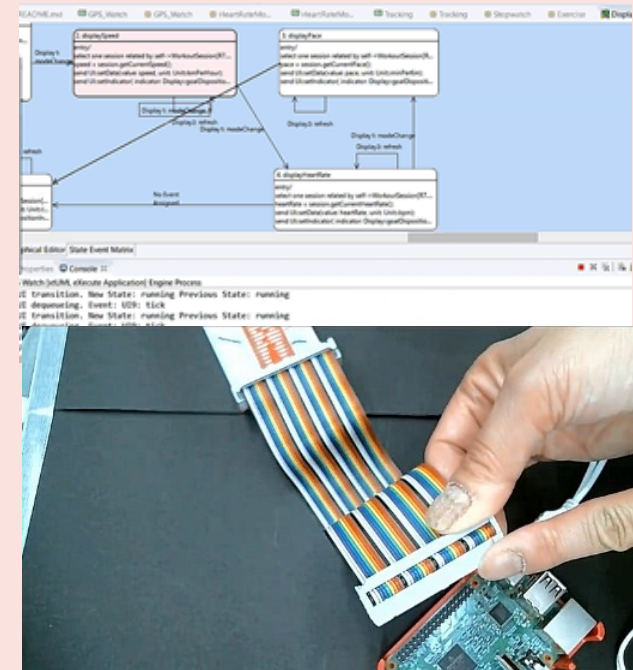
Group work without devices

- Breakout rooms in Zoom
- Online collaboration using Google documents



Individual work with devices

- Change to individual exercise by shipping devices
- On-demand videos and live-stream of lecturer's instructions



MOOC and on-demand lectures

JMOOC/gacco



- 13 lecture courses
- 20,000-30,000 learners/year
- In Japanese

edX



- 1 lecturer
- 2,000-3,000 learners/year
- In English



WASEDA University
早稲田大学

Project-based learning (PBL)

Online group work

- Business model canvas
- Architecture design
- Cloud, AWS, Raspberry Pi
- Deep learning

Exercise in assembly format

- Team work mixing engineers and university students
- AWS Deep racer
- Reinforcement learning



2. Quality assurance in education

- Learners' course evaluations to improve each course content
- Course text review by subject matter experts
 - E.g., a course division into multiple courses
- Learner interview one year after graduation to confirm and improve entire program
 - 2019: 60-80% respondents (N=10) answered the program was useful for developing and improving their businesses.
 - 2020: 85% respondents (N=13) answered the program was useful for developing and improving their businesses.



<https://wasedaneo.jp/1692/>



<https://www.wasecom.jp/article/1294>

3. Feedback loop of education and research

Education

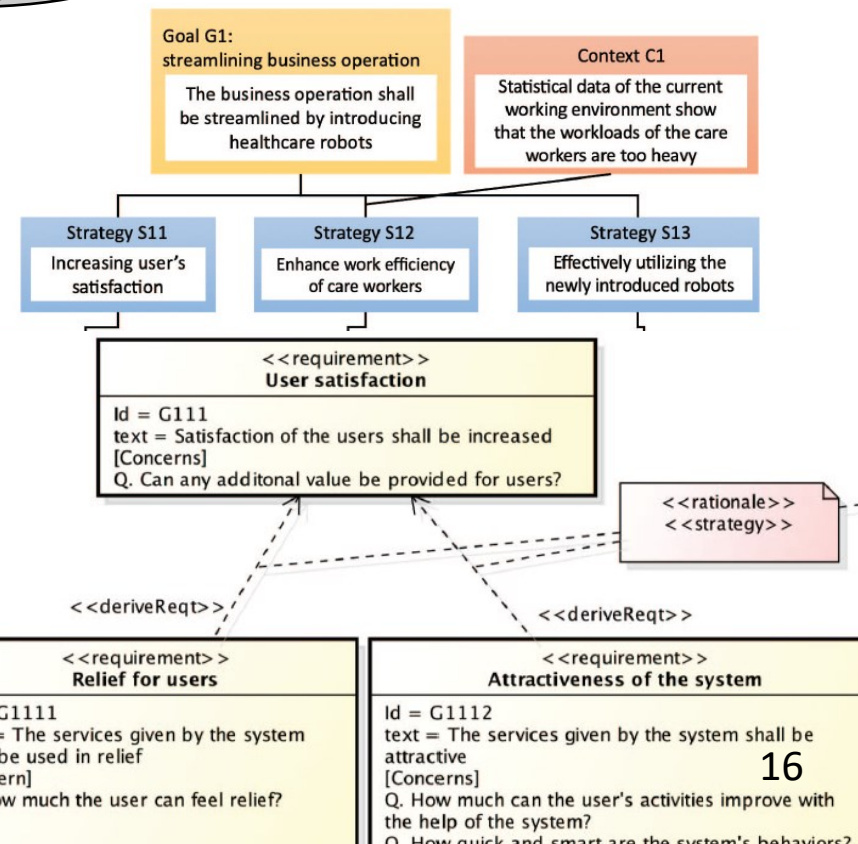
- Identifying potential problems
- E.g., IoT systems involving IoT business and systems modeling

Research

- Solving problems
- E.g., Integration of GQM+Strategies and SysML



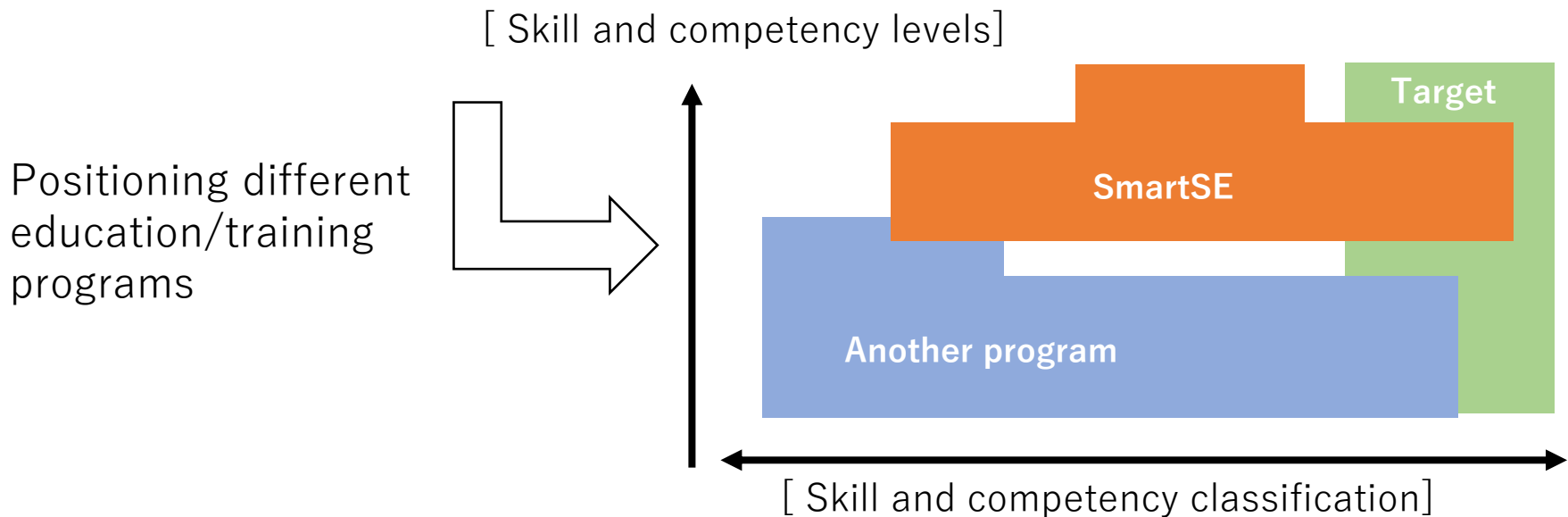
- Horizontal Relation Identification Method to Handle Misalignment of Goals and Strategies Across Organizational Units, IEEE Access 7(1), 2019
- Systematical Alignment of Business Requirements and System Functions by Linking GQM+Strategies and SysML, Int. J. Service and Knowledge Management 5(1), 2021
- Continuous modeling supports from business analysis to systems engineering in IoT development, Int. J. Service and Knowledge Management 6, 2022



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Mapping course contents to knowledge/skill/competency frameworks

- Identifying strength and weakness (and potential extension) of the program
- Reference frameworks
 - Bodies of Knowledge: SWEBOK, INCOSE SE Handbook, PMBOK, ...
 - Skill framework: **SFIA framework**, e-CF, ...
 - Competency framework: i Competency Dictionary (iCD), SWECOM, ...



SFIA: Skills Framework for the Information Age

- Global de facto standard IT Skill Framework for industry
 - Used more than 200 countries
 - Translated in 11 languages
 - <https://sfia-online.org/en>
- Free of charge for most non-commercial uses. Charged for business users
- National IT Skill Standard in Australia, Saudi Arabia etc.
- the globally accepted common language for the skills and competencies for the digital transformation world.

History

2021 – SFIA V8

2018 – SFIA V7

2015 – SFIA V6

2011 – SFIA V5

2008 – SFIA V4

2005 – SFIA V3

2003 – SFIA Foundation

Formed

2001 – SFIA V2

2000 – SFIA V1

1990 – 1998 Various UK initiatives

SFIA : Contents

6 Categories

Strategy and architecture (27)

Change and transformation(12)

Development and implementation(20)

Delivery and operation(20)

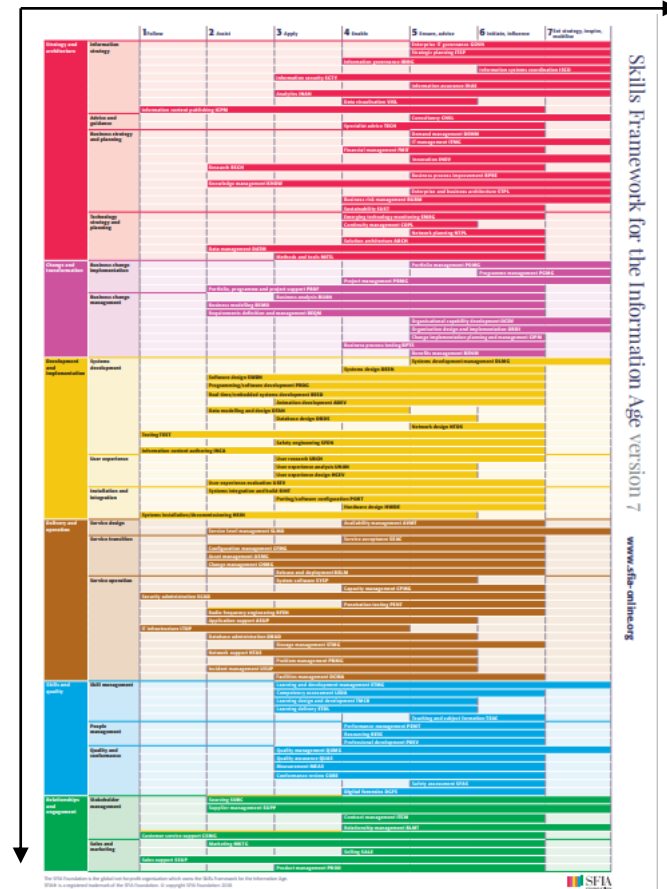
Skills and quality(14)

Relationships and engagement(9)

102 Skills

SFIA Skill= Competency

7 Level of Responsibilities (LoR)



SFIA : SFIA View <https://sfia-online.org/en>

SFIA You are here: [Home](#) / [Tools and resources](#) / [SFIA Views](#) / [Digital transformation skills in SFIA](#)

The SFIA framework

Tools and resources

Digital transformation skills in SFIA

organisational outcomes such as more profitable business models, more access to markets, enhanced offerings to users, and new sources of revenue. Digital transformation is to support business and HR leaders who are designing and delivering a

ation Skills in SFIA

CONTENTS

1. Digital transformation skills in SFIA
2. SFIA is not only for IT
3. How does SFIA support organisations planning and executing Digital business transformation
4. Using SFIA to improve Digital Transformation job descriptions.
5. SFIA is flexible
6. Digital innovation, strategy and investment
7. Digital culture, digital skills and capabilities
8. Digital & data transformation, change and governance
9. Digital technology enablers
10. Why don't SFIA skills have Digital in their name?
11. Illustrative Digital transformation knowledge-based requirements
12. Why use SFIA instead of creating a new stand-alone Digital skills framework?
13. Summary of changes to SFIA-7

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News

About us

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SFIA

The SFIA framework

Tools and resources

Using SFIA

You are here: [Home](#) / [Tools and resources](#) / [SFIA Views](#) / [Big Data/Data Science skills in SFIA](#)

Big Data/Data Science skills in SFIA

Big data is data that contains a greater variety arriving in increasing volumes and with ever-higher velocity. Data is processed and get value from the data through the application of a variety of methods including computer science, machine learning and data visualisation.

ata Skills in SFIA

CONTENTS

- Data governance
- Data culture change and organisational capability development
- Data lifecycle management
- Data foundations
- Data management jobs and skills profiles
- Using SFIA to improve Big Data/Data Science job descriptions.
- Standard or model skills profiles for Big Data/Data Science roles
- Where is the Data Science skill in SFIA?
- Listing of potential Big Data/Data Science Skills

Licensing SFIA

Get help

Get accredited

News

Click on image to see full-size interactive pdf with hyperlinked skill names.



Exemplar mapping: Smart SE on SFIA DX view

- Smart SE IoT/AI courses cover 11 out of 49 skills in SFIA DX view
 - Digital tech. 33%, digital strategy 29%, digital/data 21%

Category	Skill	IoT business model	IoT innovation
<u>Digital strategy, innovation and investments</u>	<u>Strategic planning</u>		
	<u>Innovation</u>		Service innovation design
	<u>Emerging technology monitoring</u>		
	<u>User research</u>	Interview and hypothesis verification	
	<u>User experience design</u>		
	<u>Business process improvement</u>		
	<u>Business situation analysis</u>	Business model canvas	
	<u>Demand management</u>		
	<u>Portfolio management</u>		
	<u>Feasibility assessment</u>	Lean startup	
	<u>Investment appraisal</u>		
	<u>Enterprise and business architecture</u>		
	<u>Product management</u>		
	<u>Marketing</u>		

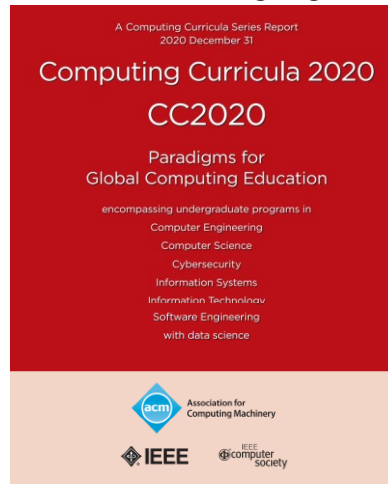
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Comparison of required skills and competencies between Industry and University

University



CC2020



Industry



SFIA V7



Comparison



Competency vs Competency

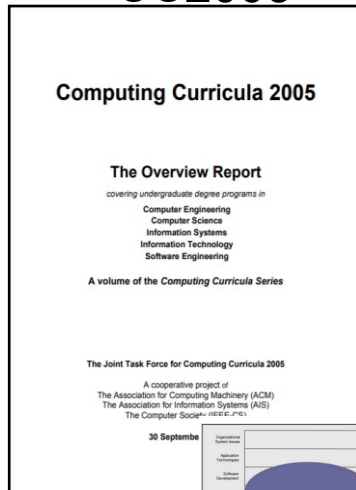
Competency =
“I can do this”

**The IT Curriculum Global Standard
(ACM and IEEE-CS)**

**The IT Skill Framework Global
de facto Standard (SFIA
Foundation)**

CC2020: Computing Curricula

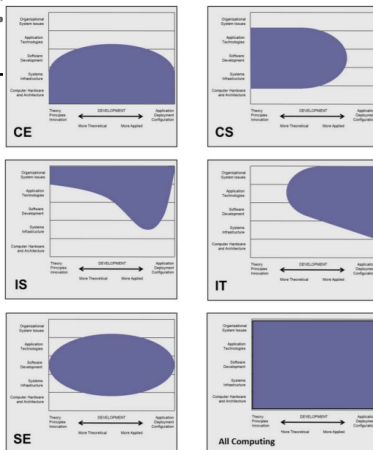
CC2005



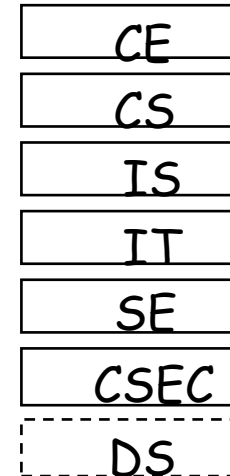
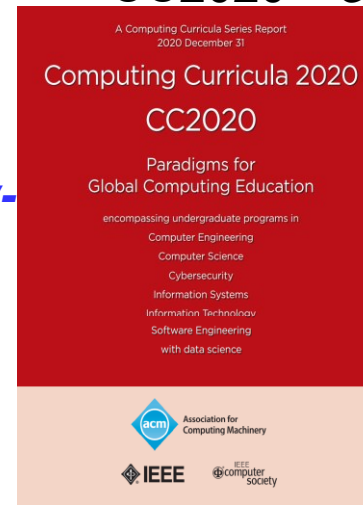
a task force of 50 people
from 20 countries

*knowledge-
based*

*competency-
based*



CC2020 Computing Disciplines

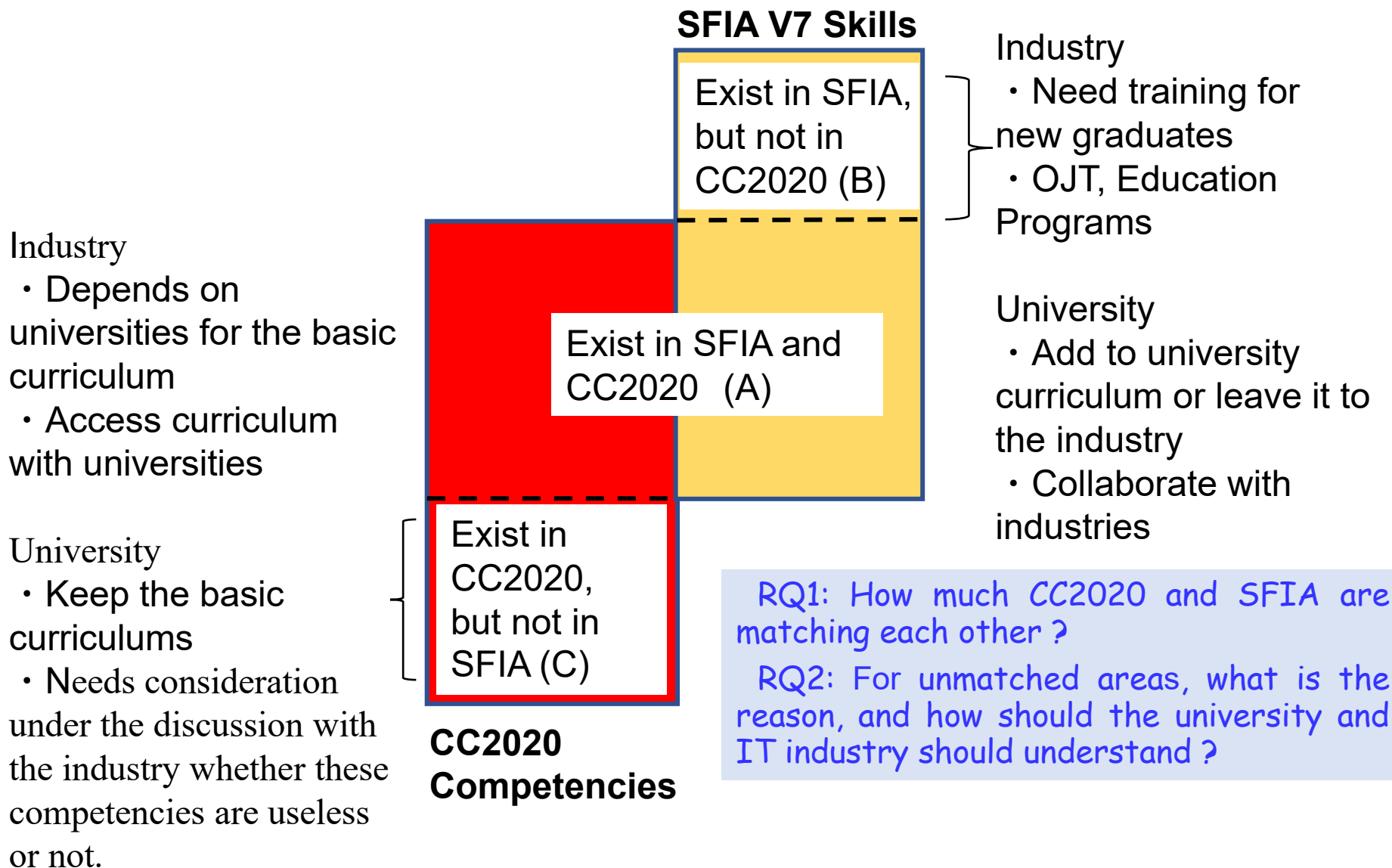


Competency = Knowledge + Skills + Dispositions

- Knowledge—"know-what"
- Skills—"know-how"
- Dispositions—"know-why"

- Computer Engineering Curricula 2016 (CE2016)
- Computer Science Curricula 2013 (CS2013)
- Information Systems 2010 (IS2010)
- Information Technology Curricula 2017 (IT2017)
- Software Engineering Curricula 2014 (SE2014)
- Cybersecurity Curricula 2017 (CSEC2017)
- (• Data Science Curricula 2021 (DS2021))

Comparison: CC2020 vs SFIA V7

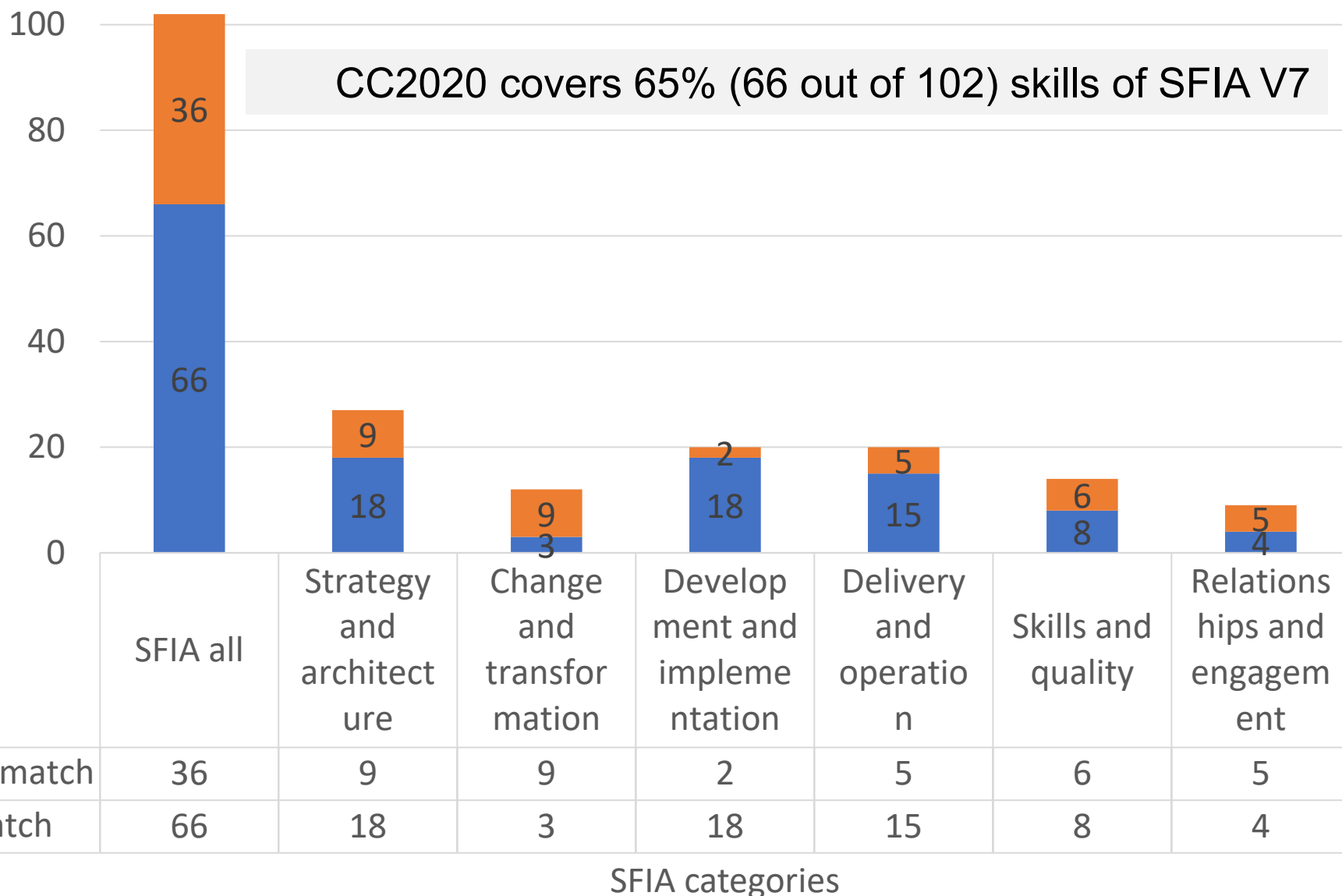


(A)



RQ1 : How much CC2020 and SFIA are matching each other ? (A) (cont.)

of SFIA skills matching/unmatching to CC2020



RQ2:For the unmatched area, what is the reason? (B)

Unmatched skills

- Business-related Skills 10(28%)
- Organization-related Skills 18(50%)
- Advanced technology-related Skills 8(22%)

← SFIA 36 skills unmatched to CC2020 →

Skill Category	Strategy and architecture								Change and transformation								Development and implementation	Delivery and operation				Skills and quality				Relationships and engagement										
Skill Name	Information systems coordination ISCO	Analytics INAN	Data visualization VISL	Information content publishing ICPM	Consultancy CNSL	Specialist advice TECH	Financial management FMIT	Research RSCH	Sustainability strategy SUST	Portfolio management POMG	Programme management PGMG	Business analysis BUAN	Business modelling BSMO	Organizational capability development OCDEV	Organisation design and implementation ORDI	Change implementation planning and management CIPM	Business process testing BPTS	Benefits management BENM	Animation development ADEV	Porting/software configuration PORT	Change management CHMG	Release and deployment RELM	Radio frequency engineering RFEN	Problem management PBMG	Incident management USUP	Learning design and development TMCR	Learning delivery ETDL	Teaching and subject formation TEAC	Professional development PDSV	Measurement MEAS	Conformance review CORE	Customer service support CSMG	Marketing MKTG	Selling SALE	Sales support SSUP	Product management PROD
Unmatched Reason	2	3	3	2	1	2	2	3	2	2	2	1	1	2	2	2	1	1	3	3	2	3	3	3	2	2	2	2	2	1	2	2	1	1	1	1

RQ2: For the unmatched area, what is the reason? (C)

	Category	SFIA
CE	CE-CAE Circuits and Electronics	
	CE-CAL Computing Algorithm	
	CE-CAO Computer Architecture & Organization	
	CE-DIG Digital Design	
	CE-ESY Embedded System	
	CE-NWK Computer Networks	✓
	CE-PPP Preparation for Professional Practice	
	CE-SEC Information Security	
	CE-SGP Signal Processing	
	CE-SPE Systems and Project Engineering	✓
	CE-SRM System Resource Management	✓
	CE-SWD Software Design	✓
CS	AL-Algorithms and Complexity	
	AR-Architecture and Organization	
	CN-Computational Science	
	DS-Discrete Structure	
	GV-Grapsics and Visualization	✓
	HCI-Human-Computer Interaction	✓
	IAS-Information Assurance and Security	
	IM-Information Management	✓
	IS-Intelligent Systems	
	NC-Networking and Communication	✓
	OS-Operating Systems	
	PBD-Platform-based Development	✓
	PD-Parallel and Distributed Computing	
	PL-Programming Languages	✓
	SDF-Software Development Fundamentals	✓
	SE-Software Engineering	✓
	SF-Sytems Fundamentals	✓
	SP-Social Issues and Professional Practice	✓
IS	Identifying and designing opportunities for IT-enabled organizational improvement	✓
	Analyzing trade-offs	✓
	Designing and improving information systems solution	✓
	Managing ongoing information technology operations	✓
	Leadership and collaboration	✓
	Communication	
	Negotiation	
	Analytical and critical thinking, including creativity and ethical analysis	
	Mathematical foundations	

SFIA V7 covers 68% (49 out of 72) competencies of CC2020

Unmatched reasons:

- Fundamental Science Competencies 10 (28%)
- SFIA LoR definition, not SFIA skills 4 (17%)
- Competency unknown 1 (4%)
- Not Industrial Issues 2 (9%)

RQ2: For the unmatched area, what is the reason? (C) (cont.)

39

	Category	SFIA
IT	ITE-CSP Cybersecurity Principles	✓
	ITE-GPP Global Professional Practices	✓
	ITE-IMA Information Management	✓
	ITE-IST Integrated Systems Technology	✓
	ITE-NET Networking	✓
	ITE-PFT Platform Technologies	✓
	ITE-SPA System Paradigms	✓
	ITE-SWF Software Fundamentals	✓
	ITE-UXD User Experience Design	✓
	ITE-WMF Web and Mobile Systems	✓
SE	Software Requirement	✓
	Software Design	✓
	Software Construction	✓
	Software Testing	✓
	Software Sustainment	✓
	Software Process and Life Cycle	✓
	Software Systems Engineering	✓
	Software Quality	✓
	Software Security	✓
	Software Safety	✓
	Software Configuration Management	✓
	Software Measurement	✓
	Human-Computer Interaction	
	Project Management	✓
	Behavioral Attributes	✓
CSEC	Data	✓
	Software	✓
	Component	✓
	Connection	✓
	System	✓
	Human	
	Organizational	✓
	Societal	

SFIA V7 covers 68% (49 out of 72) competencies of CC2020

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- Competency unknown 1 (4%)
- Not Industrial Issues 2 (9%)

- Smart SE: Recurrent education of IoT and AI for Business
 - DX and 60-year curriculum
 - Comprehensive program sets: MOOC and PBL
 - Quality assurance
- Mapping course contents to skill and competency frameworks to identify strengthen and weakness
 - SFIA: Skills Framework for the Information Age
 - Smart SE IoT/AI courses cover 22% (11 out of 49) skills in SFIA V8 DX view
- Comparison of required skills and competencies between Industry and Academia
 - CC2020 covers 65% (66 out of 102) skills of SFIA V7
 - SFIA V7 covers 68% (49 out of 72) competencies of CC2020

<https://www.waseda.jp/inst/smartse/en>

“Smart SE: Smart Systems and Services Innovative Professional Education Program,” COMPSAC 2020

“Automated educational program mapping on learning standards in computer science,” COMPSAC 2021

“The Competency-based Computing Curricula 2020 and SFIA V7 comparison focusing on Digital Transformation Age,” EDUNINE 2022