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Smart SE: Recurrent Education Program of IoT and AI for Business in the Era of Digital Transformation and 60-Year Curriculum

WASEDA University

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

Prof. Dr. Hironori Washizaki

- Professor and the Associate Dean of the Research Promotion Division at Waseda University in Tokyo
- Visiting Professor at the National Institute of Informatics
- Outside Directors of SYSTEM INFORMATION and eXmotion
- **Leading Smart SE**
- Leading projects on STEM education with a particular focus on introductory programming environments
- IEEE Computer Society Vice President for Professional and Educational Activities
- Associate Editor of IEEE Transactions on Emerging Topics in Computing
- Editorial Board Member of MDPI Education Sciences
- Steering Committee Member of the IEEE Conference on Software Engineering Education and Training (CSEE&T)
- Advisory Committee Member of the IEEE CS flagship conference COMPSAC
- Convener of ISO/IEC/JTC1 SC7/WG20
- http://www.washi.cs.waseda.ac.jp/

Smart SE : Smart Systems and Services innovative professional Education program

https://smartse.jp/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

Agenda

- Smart SE in the era of DX and 60-year curriculum
- Practical features in Smart SE
  - Comprehensive program sets
  - Quality assurance
  - Feedback loop of education and research
- Related activities in IEEE-CS PEAB

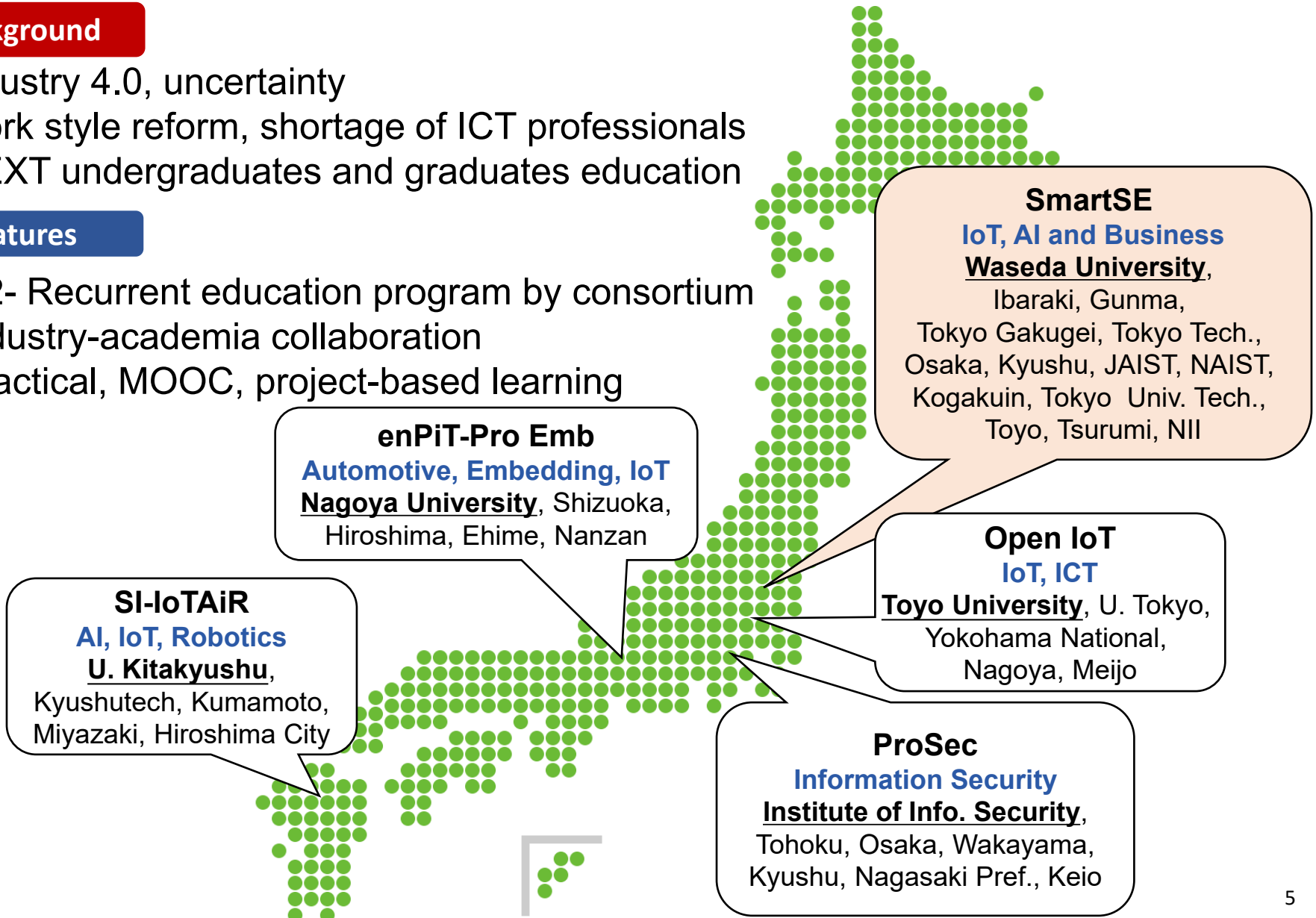
enPiT-Pro: Systematic, advanced, and short-term ICT practical recurrent education program with industry-academia network in Japan

Background

- Industry 4.0, uncertainty
- Work style reform, shortage of ICT professionals
- MEXT undergraduates and graduates education

Features

- ’22- Recurrent education program by consortium
- Industry-academia collaboration
- Practical, MOOC, project-based learning



Background and related programs in Waseda University

Industrial needs

- Crucial needs of professional engineers in IoT, BigData and AI
- Difficulty in utilizing data and leading data-driven innovation不足

Vision of Japanese goverment

- Society 5.0: super smart society
- 4th industrial evolution

International situations

- Highly technology competitive environments
- Global human resource markets

Graduates and post-doctors

Industrial engineers

D-Data: data scientists program

EDGE-NEXT: innovation and entrepreneurship program

enPiT-Pro Smart SE

Data Science Research and Education Center

WASEDA VISION 150

Educating global leaders

Digital transformation (DX)

- 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.

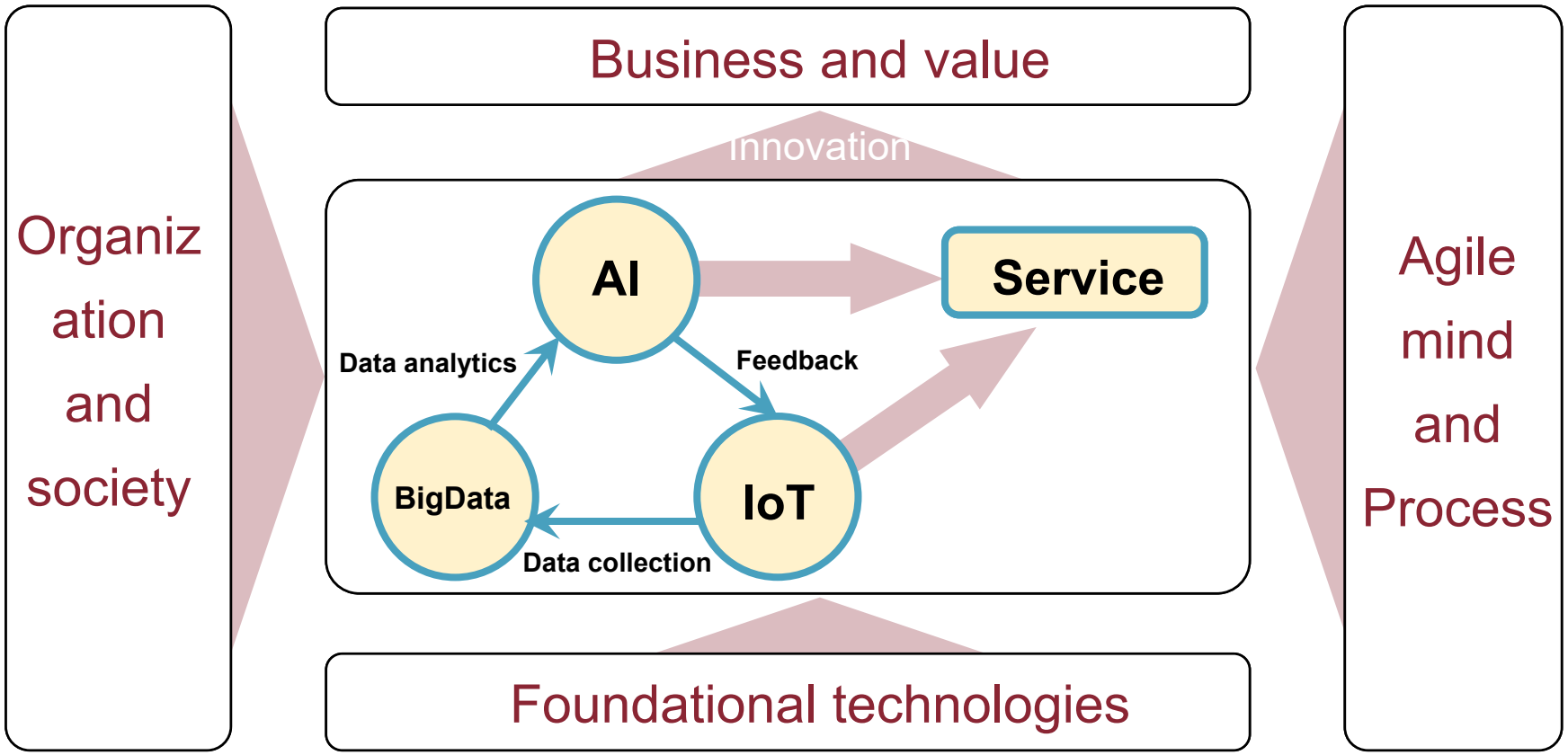
60-year curriculum: New perspective on continuing education

- 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

https://er.educause.edu/articles/2020/10/the-60-year-curriculum-a-strategic-response-to-a-crisis

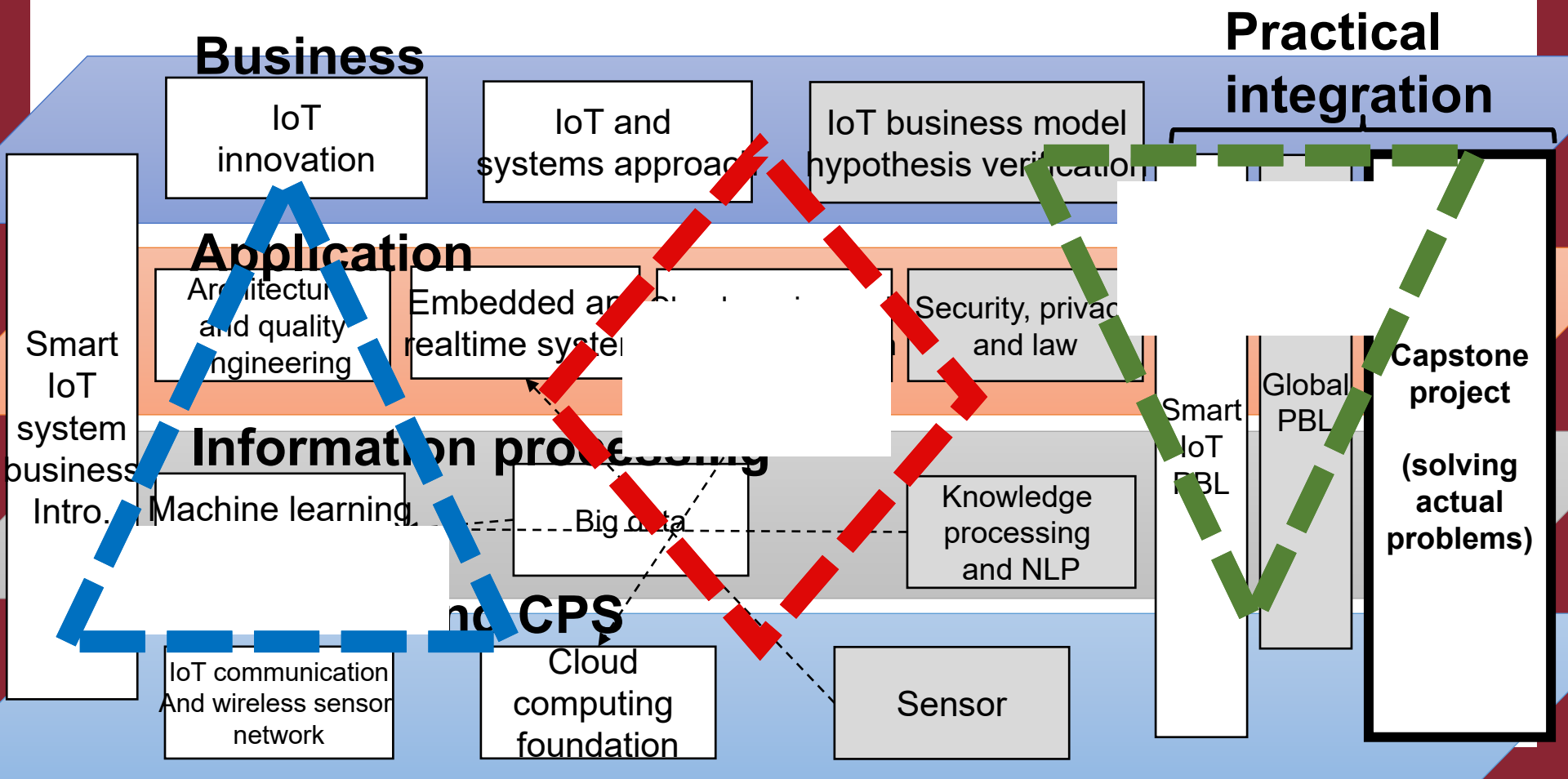
Smart SE: Recurrent Education Program of IoT and AI for Business in the era of DX

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



Curriculum over different layers in digital transformation (DX) era

Necessary viewpoint	Data-driven and comprehensive approach	Connection with Businesses and values	Various objectives and contexts
Solution	Full-stack curriculum and common problems	Business and design thinking, PBL, capstone	Ease of course combinations, on-demand



Human resources who will lead the creation of value through the provision of smart systems and services: Full-stack engineers with expertise (three types)

* Smart systems and services: Services that respond to specific and detailed needs, and systems that accommodate those services and deliver them efficiently

Prerequisites

- Applicants must pass an entrance test equivalent to the intermediate-level MCPC IoT technology certification exam (Students who are expected to pass will be admitted under the condition that they will take an introductory course)
- Actual work experience in information technology

Anticipated participants

Those who have a fundamental knowledge of information systems

Human resource model (1)

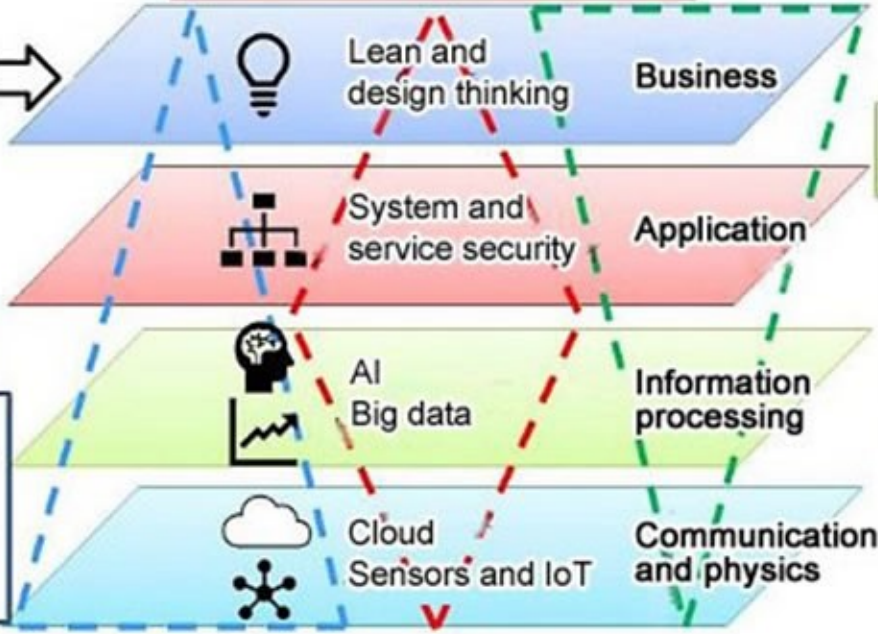
Professionals of embedded systems and IoT

Design and build IoT systems that combine sensors and cloud computing, with a focus on business and innovation

Human resource model (2)

System of systems and quality architects

Creating an integrated system out of a group of systems, performing multifaceted quality evaluations for systems including security, and making improvements through big data analysis



Completion requirements

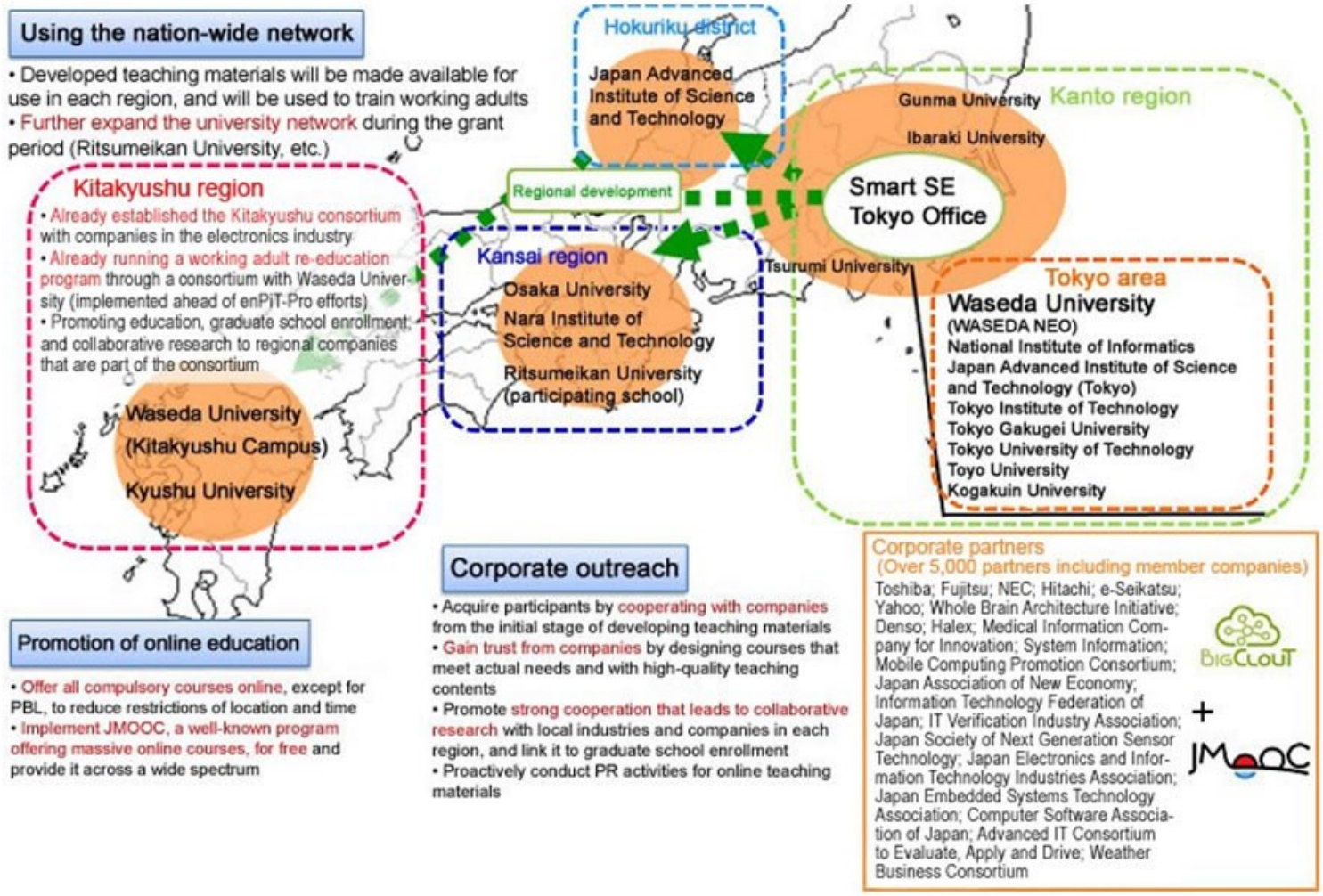
- Knowledge level equivalent to the advanced-level MCPC IoT technology certification exam is evaluated at each subject category.
- Demonstrate the ability to create value with a course completion project

Human resource model (3)

Cloud business innovator

Make future predictions by applying AI to analyze big data, and design and verify business models that offer adaptive services via cloud computing

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



Agenda

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  - Quality assurance
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Practical features in Smart SE

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
   - Review of entire program based on reference frameworks
3. Feedback loop of education and research
   - Individual subject (e.g., integrated modeling method)
   - Automated review of entire program

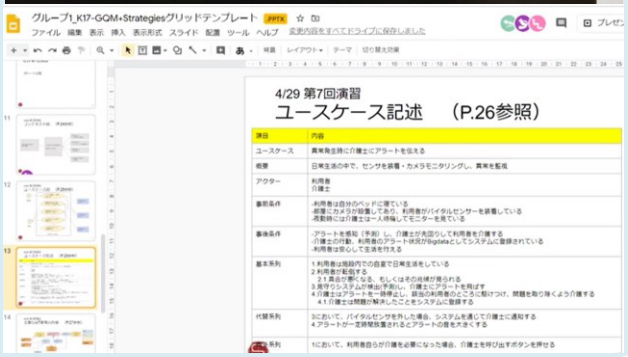
1. Blended learning

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

ONLINE REAL

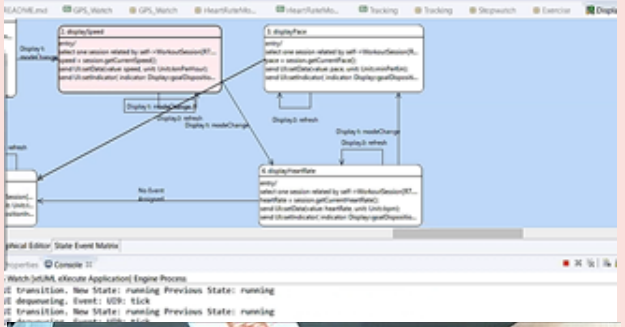
Group work without devices

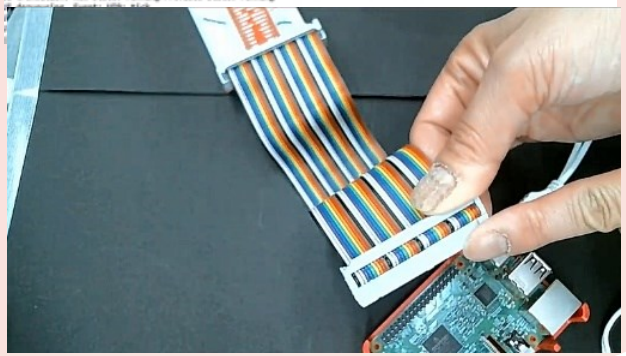
- Breakout rooms in Zoom
- Online collaboration using Google documents



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

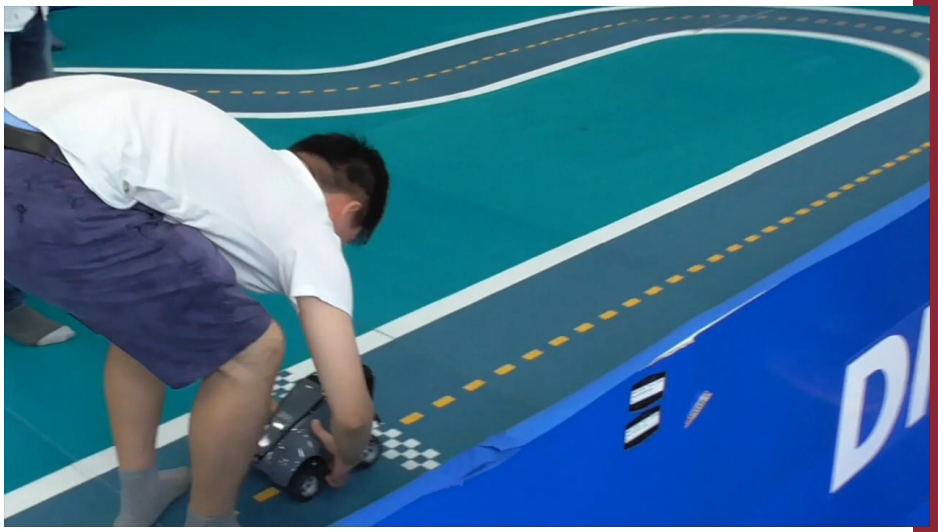
edX

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

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



https://smartse.jp/information/2019/110519111102842/

Comprehensive program sets

	Regular	JMOOC/gacco	edX
Lecture courses	15 courses and 2 projects	13 courses	1 course
Learning methods	Live-stream, on-demand, assembly format	On-demand only, no exercise	On-demand only, no exercise
Duration	6 hours/week	3 hours/week	3-5 hours/week
Course periods	6 months	3 months	2 months
Capacity	30 learners	No limit	No limit

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.

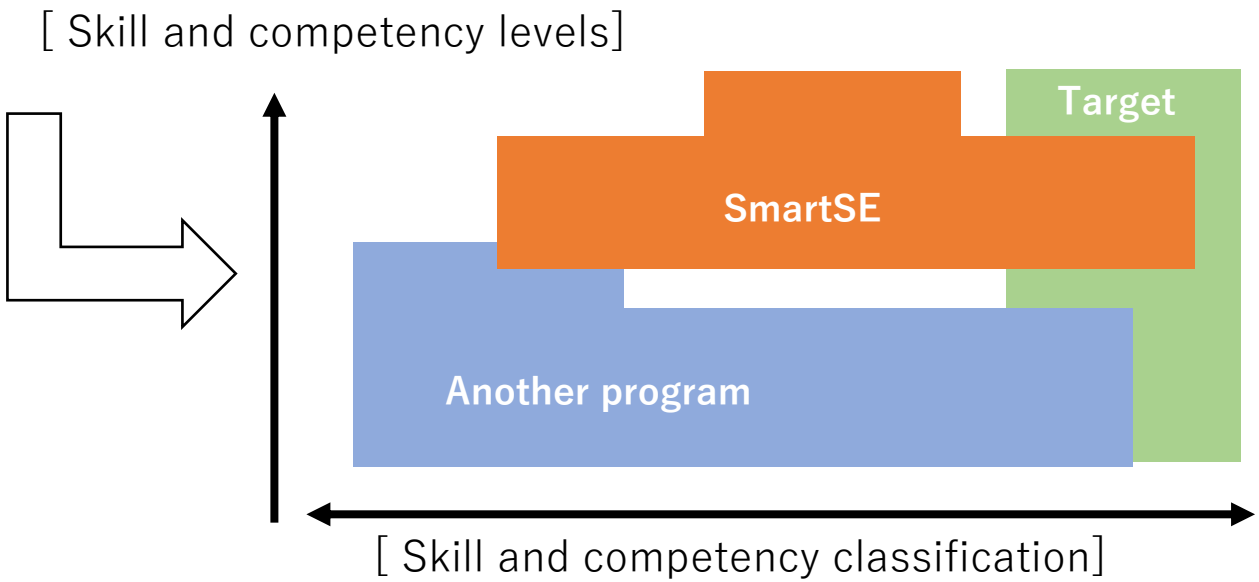
https://wasedaneo.jp/1692/

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

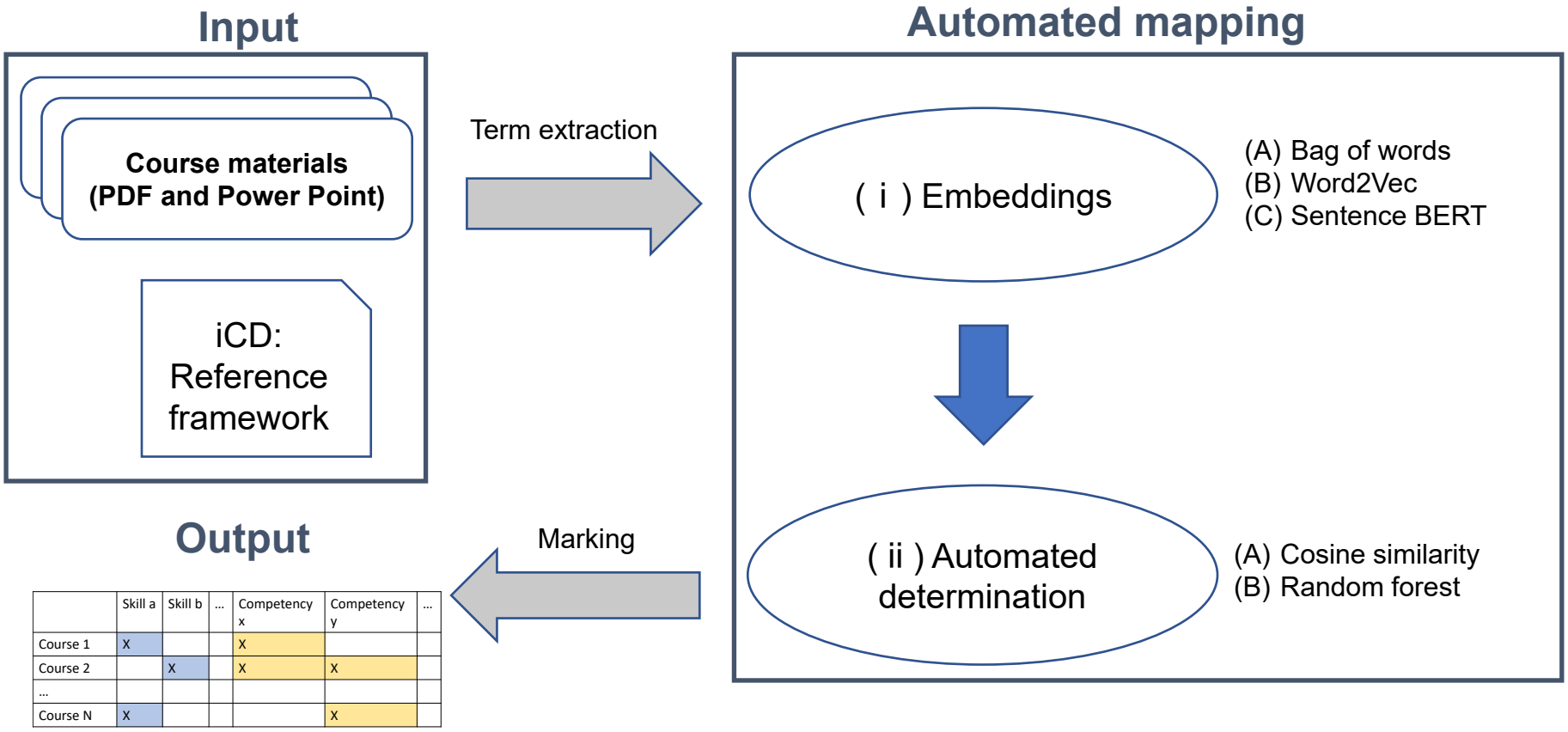
Mapping course contents to knowledge/skill/competency frameworks

- 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, …

Positioning different education/training programs



Research: Automated course mapping by NLP and machine learning



	Skill a	Skill b	...	Competency x	Competency y	...
Course 1	X			X		
Course 2		X		X	X	
...						
Course N	X				X	

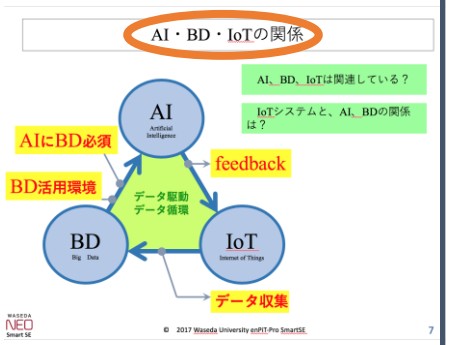
Mapping result based on frameworks

"Automated educational program mapping on learning standards in computer science," 45th IEEE Computer Society Signature Conference on Computers, Software and Applications (COMPSAC 2021), Fast Abstract

i. Embeddings

Input

Text and slides



List of skills and competencies

スキル項目
ビジネス環境分析手法
ビジネス戦略と目標・評価
業界動向把握の手法
経営管理システム
経営戦略手法
最新技術動向把握の手法
市場調査手法
ブランド・製品戦略手法
マーケットコミュニケーション戦略手法

Sentence extraction

"AI, BD, IoT are related … "

Tokenization

[AI, BD, IoT, are, related, …]

(A) BoW

[0 0 0 1 0 1 1 0 0 1・・・]

or

(B) Word2Vec

[[-0.187 -0.003 ・・ 0.314
0.147 ・・・・・ 0.051
-0.399 0.183 ・・ 0.152],
[・・・],
[・・・]]

Average

[[-0.126 0.220 ・・ 0.104
0.127 ・・・・・ 0.004
-0.322 0.108 ・・ 0.032],

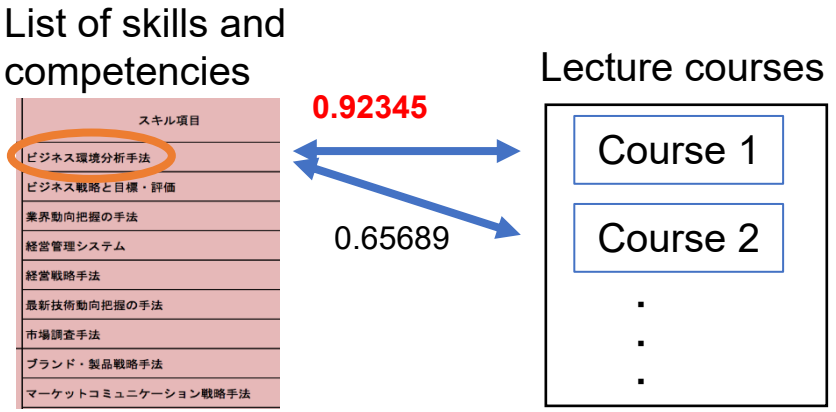
(c) Sentence BERT

[-0.051 0.068・・ 0.083 -0.215
0.097 ・・・・・・・ 0.004
・
・
・
0.046 ・・・・・・ -0.071
0.092 -0.057 ・・ 0.057 -0.047]

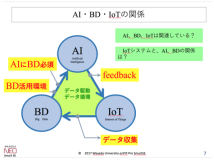
"Automated educational program mapping on learning standards in computer science," 45th IEEE Computer Society Signature Conference on Computers, Software and Applications (COMPSAC 2021), Fast Abstract

ii. Automated determination of relation

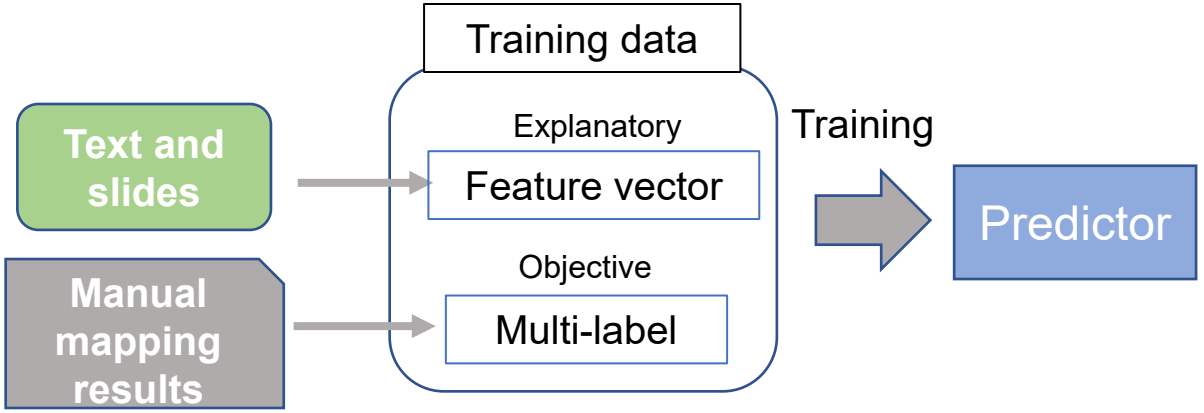
(A) Cosine similarity



(B) Random forest



	Skill a	Skill b	...	Competency x	Competency y	...
Course 1	X			X		
Course 2		X		X	X	
...						
Course N	X				X	



"Automated educational program mapping on learning standards in computer science," 45th IEEE Computer Society Signature Conference on Computers, Software and Applications (COMPSAC 2021), Fast Abstract

Experimental evaluation

- Targeting 30+ slide sets
- In terms of F-measure, combination of sentence distributed representation and supervised learning worked best.
- Need more improvement for practical usage

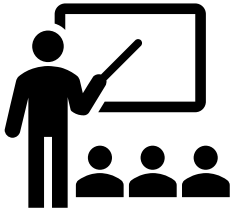
	Cosine similarity	Supervised learning (BoW)	Supervised learning (distributed representation)
Precision	0.313	0.545	0.706
Recall	0.417	0.240	0.480
F-value	0.357	0.333	0.571

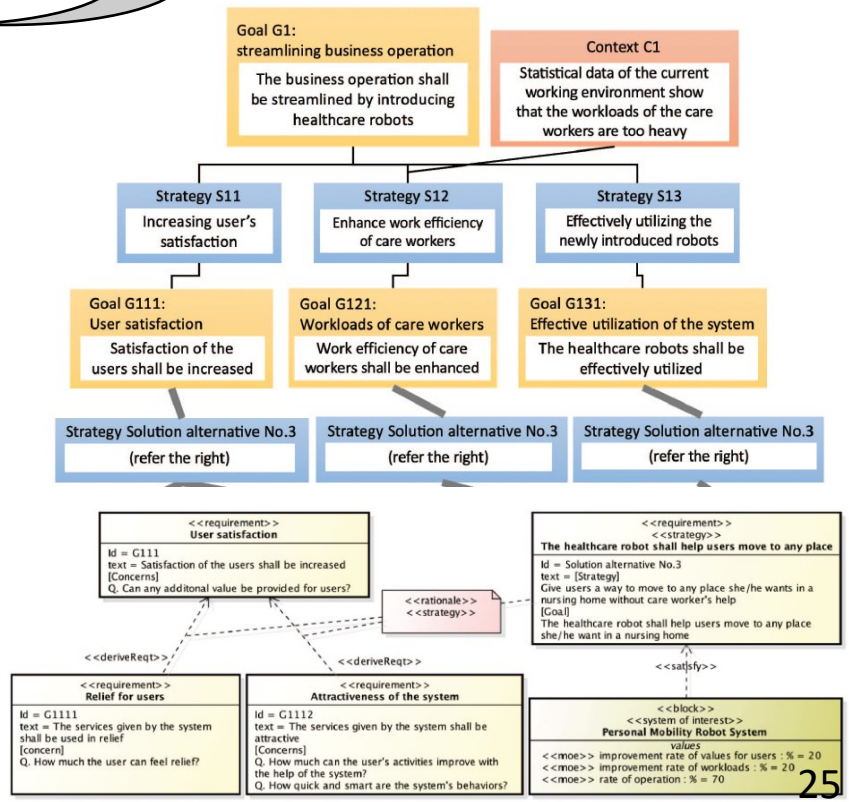
"Automated educational program mapping on learning standards in computer science," 45th IEEE Computer Society Signature Conference on Computers, Software and Applications (COMPSAC 2021), Fast Abstract

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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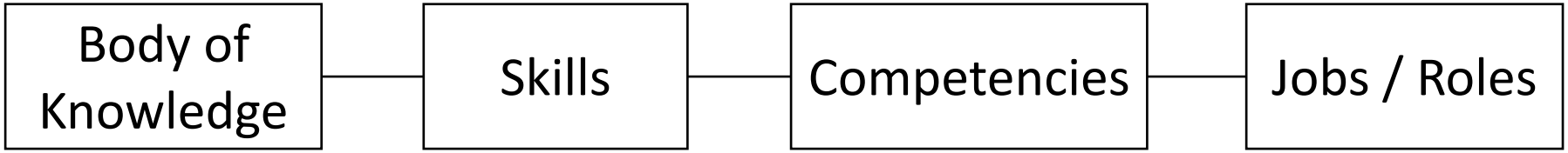
View on knowledge/skill/competency
(Ref: ISO/IEC 24773-2 [under development])



In ISO/IEC 17024 and ISO/IEC 24773-1,
Competence and competency are defined as:

Ability to apply knowledge and skills to achieve intended results.

Competency	Knowledge	Skill	Proficiency level
Competency 1	List of knowledge required to demonstrate competency 1	List of skills required to demonstrate competency 1	Proficiency level description
Competency 2	List of knowledge required to demonstrate competency 2	List of skills required to demonstrate competency 2	Proficiency level description
:	:	:	:

ISO/IEC 24773-1: 2019

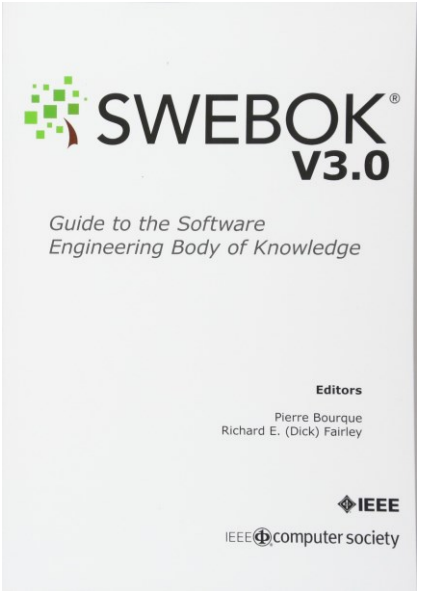
IEEE Computer Society PEAB - Professional & Educational Activities Board

- Vice President for Professional and Educational Activities: Hironori Washizaki
- Mission: Providing leadership in the Society for activities related to the professional activities of practitioners in computing disciplines
- SWEBOK V4 Evolution
  - Defining modern software engineering profession
  - Major release within 2022
- Curriculum Development and Accreditation Collaboration
  - Further development and related activities for CC2020, and related joint efforts including development of CS20XX
  - CSAB continues to operate the accreditation process
- Courses and Packages Development
  - Organizing existing training/education assets and certifications
  - Digitizing and developing training/education courses aligned with SWEBOK and other disciplines including Machine Learning
- Other BOKs and Adoption
  - Academia and industry adoption of SWEBOK
  - Further promotion and adoption of EITBOK

https://www.computer.org/volunteering/boards-and-committees/professional-educational-activities

Plan of SWEBOK evolution

- SWEBOK Guide: Guide to the Software Engineering Body of Knowledge
  - Guiding learners, researchers and practitioners to have common understanding on “generally-accepted-knowledge” in SWE
  - Defining boundary of SWE and related disciplines
  - Providing foundations for certifications and educational curriculum
- SWEBOK Guide history
  - 1998 started by IEEE CS/ACM
  - 2001 v1, 2004 v2, 2005 ISO/IEC TR 19759:2005, 2014 v3, 2015 2015 ISO/IEC TR 19759:2015
- SWEBOK Guide V3: 15 Knowledge area (KA)
  - Computing Foundations, Mathematical Foundations, Engineering Foundations
  - Software Requirements, Software Design, Software Construction, Software Testing
  - Software Maintenance, Configuration Management, Engineering Management, Engineering Process
  - Engineering Economics, Software Quality, Engineering Methods, Professional Practices



SWEBOK V3 → V4

- Defining modern software engineering profession
- Incorporating Agile into most of knowledge areas

SWEBOK V3
Requirements
Design
Construction
Testing
Maintenance
Configuration Management
Engineering Management
Process
Models and Methods
Quality
Professional Practice
Economics
Computing Foundations
Mathematical Foundations
Engineering Foundations

SWEBOK V4
Requirements
Architecture
Design
Construction
Testing
Operations
Maintenance
Configuration Management
Engineering Management
Process
Models and Methods
Quality
Security
Professional Practice
Economics
Computing Foundations
Mathematical and Engineering Foundations

Summary

- Smart SE: Recurrent Education Program of IoT and AI for Business
  - DX and 60-year curriculum
  - Comprehensive program sets: MOOC and PBL
  - Quality assurance: course evaluation and mapping on reference frameworks
  - Feedback loop of education and research
- Related activities in IEEE-CS PEAB
  - SWEBOK evolution
  - Curriculum Development and Accreditation Collaboration
  - Courses and Packages Development

Further information

- Smart SE: https://smartse.jp/ https://www.waseda.jp/inst/cds/
- Hironori Washizaki, Kenji Tei, Kazunori Ueda, Hayato Yamana, Yoshiaki Fukazawa, Shinichi Honiden, Shoichi Okazaki, Nobukazu Yoshioka, Naoshi Uchihira, Smart SE: Smart Systems and Services Innovative Professional Education Program, 2020 IEEE 44th Annual Computers, Software, and Applications Conference (COMPSAC2020), pp.1113-1114, 13-17 July 2020
- Hironori Washizaki, “Towards Software Co-Engineering by AI and Developers,” in “Handbook on Artificial Intelligence-Enhanced Software Engineering,” edited by Maria Virvou, et al., Learning and Analytics in Intelligent Systems bookseries, Springer, pp. 1-16, 2021.
- Koki Miura, Daisuke Saito, Hironori Washizaki and Yoshiaki Fukazawa, “Automated educational program mapping on learning standards in computer science,” 45th IEEE Computer Society Signature Conference on Computers, Software and Applications (COMPSAC 2021), Fast Abstract, pp. 1-2, 2021.