The Thirteenth International Conference on Mobile, Hybrid, and On-line Learning
eLmL 2021: https://www.iaria.org/conferences2021/eLmL21.html
July 18, 2021 to July 22, 2021 - Nice, France

# Blended Learning of IoT and AI for Business in Recurrent Education Program “Smart SE”

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WASEDA University

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 a large-scale grant at MEXT enPiT-Pro 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
■ 13 Partner universities
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; Kougakuin University; Tokyo University of Technology; Toyo University; Tsurumi University; National Institute of Informatics
■ 21 Partner companies and organizations
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
■ 2 Supporters
Ritsumeikan University; The BigClouT Project (EU, NICT)

# Agenda

- Overview of SmartSE
- Practical features in SmartSE
  - Comprehensive program sets
  - Quality assurance
  - Feedback loop of education and research
- Related activities in IEEE-CS PEAB

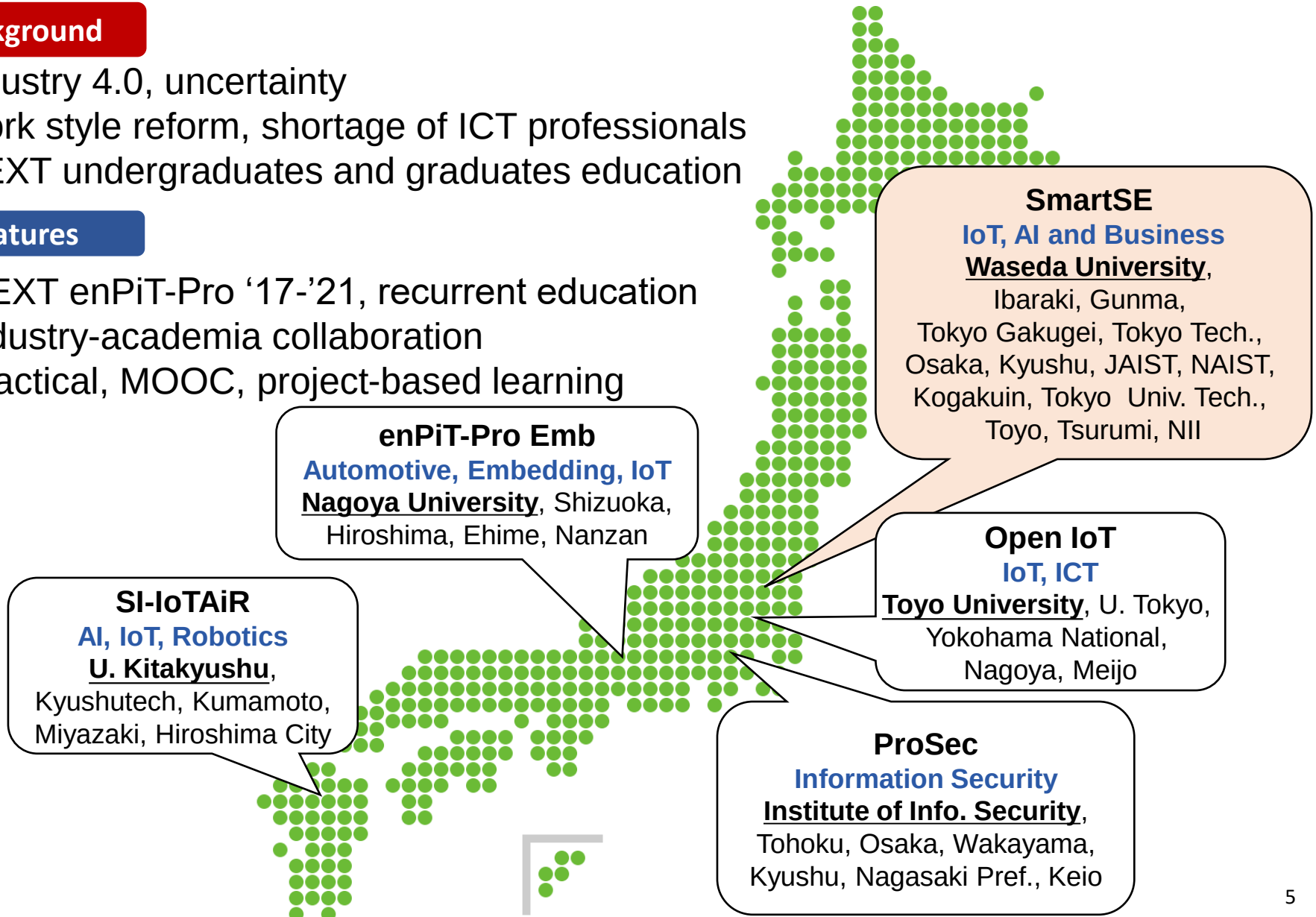
# enPiT-Pro: Systematic, advanced, and short-term ICT practical recurrent education program with industry-academia network in Japan

**Background**

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

**Features**

- MEXT enPiT-Pro '17-'21, recurrent education
- 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

Industrial engineers

Graduates and post-doctors

**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

# Smart SE: Educating Professionals

PI: Prof. Washizaki, 3M USD

14+ universities

16+ collaborators

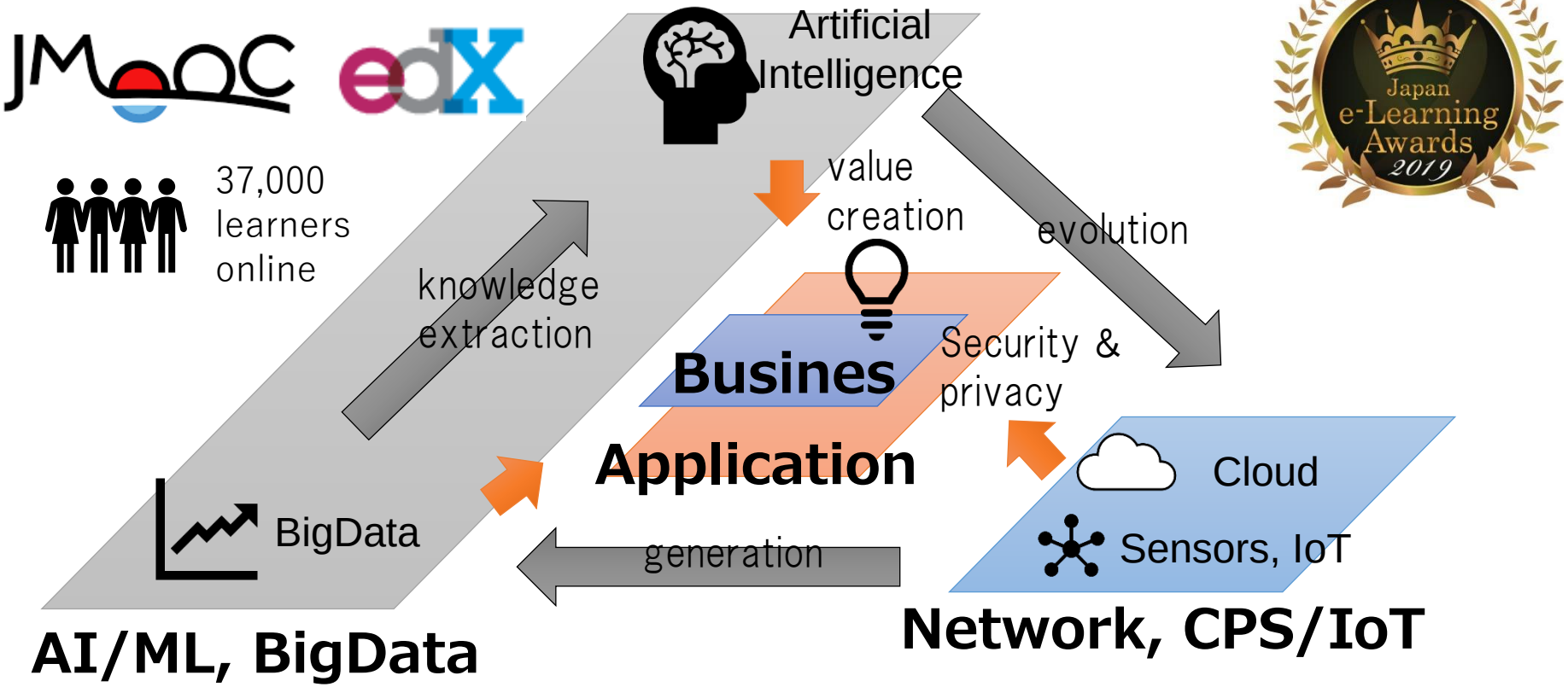
16 classroom courses

13 Japanese online courses

1 English online course

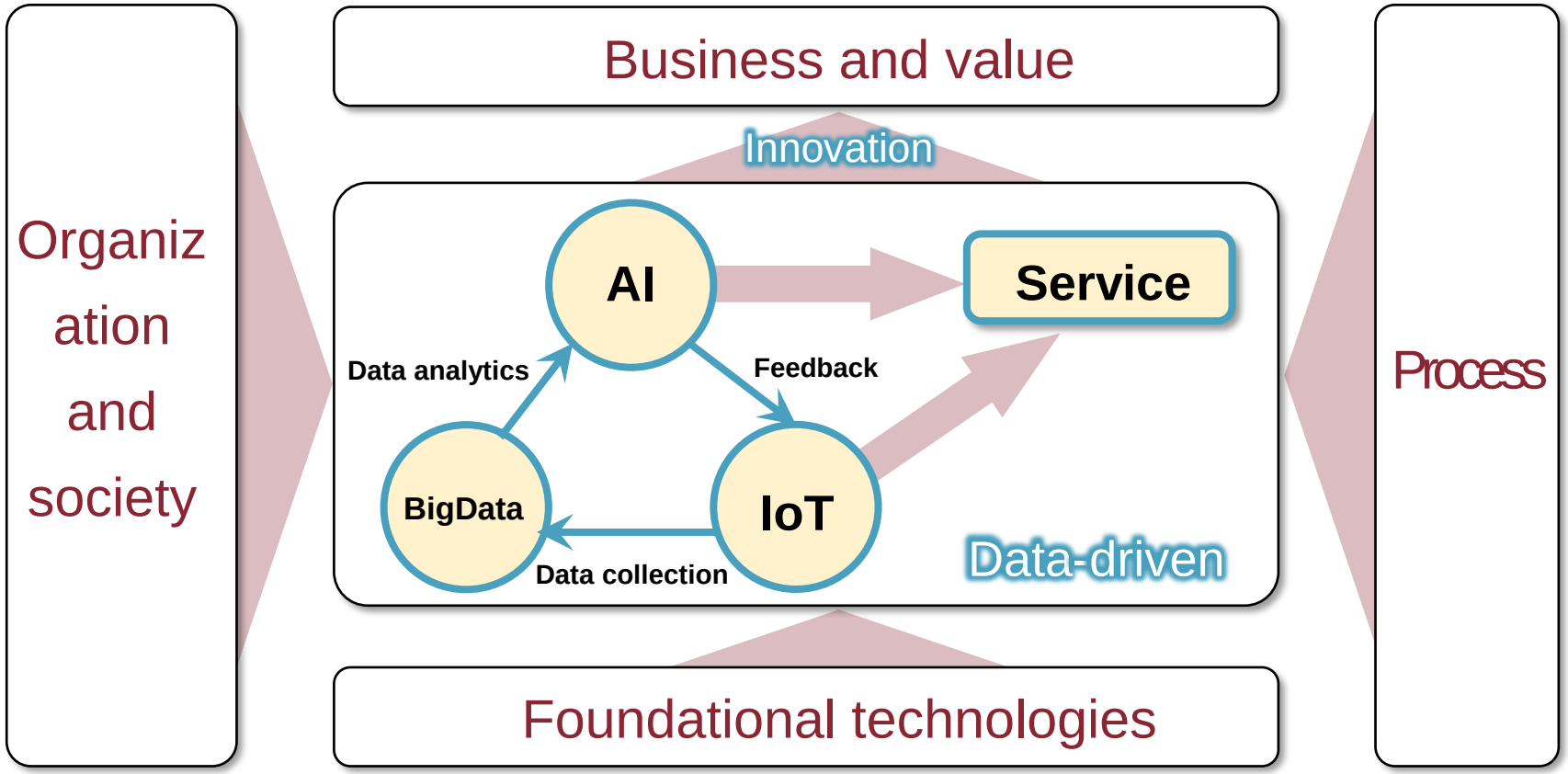
37,000 learners online

IMS Japan, e-Learning award



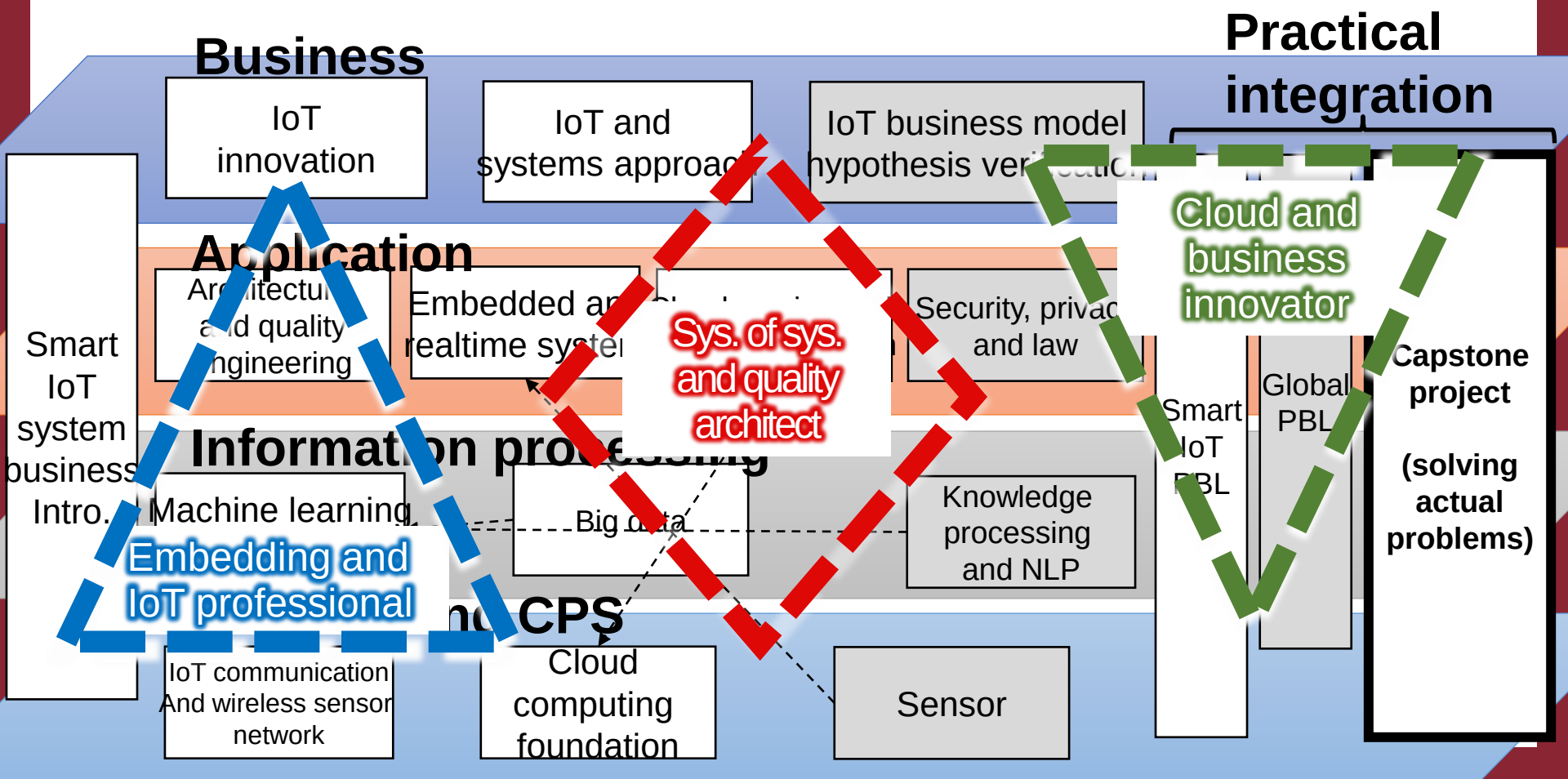
# Smart SE: Recurrent Education Program of IoT and AI for Business

AI, IoT and other advanced digital technologies



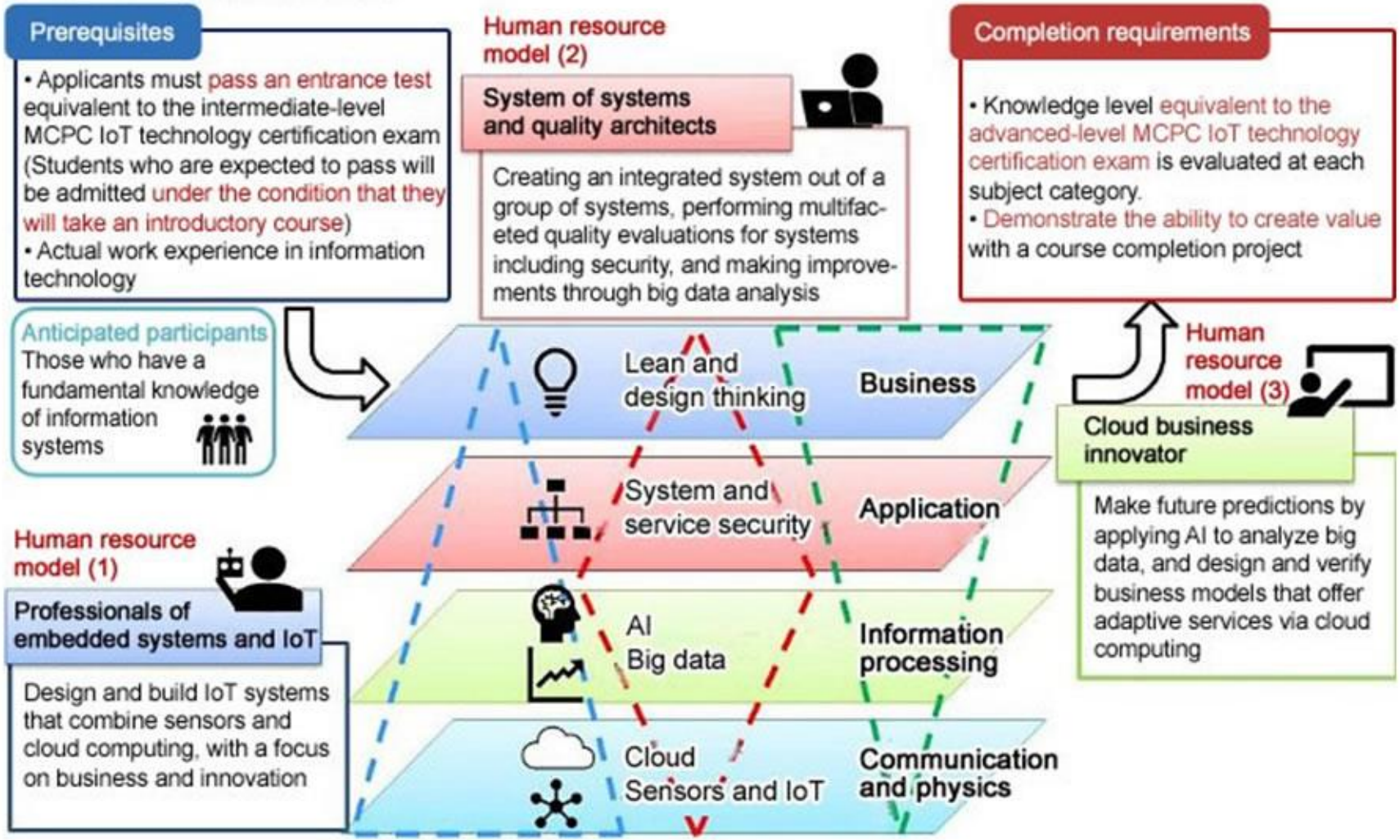
# Curriculum over different layers in digital transformation (DX) era

| 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 |

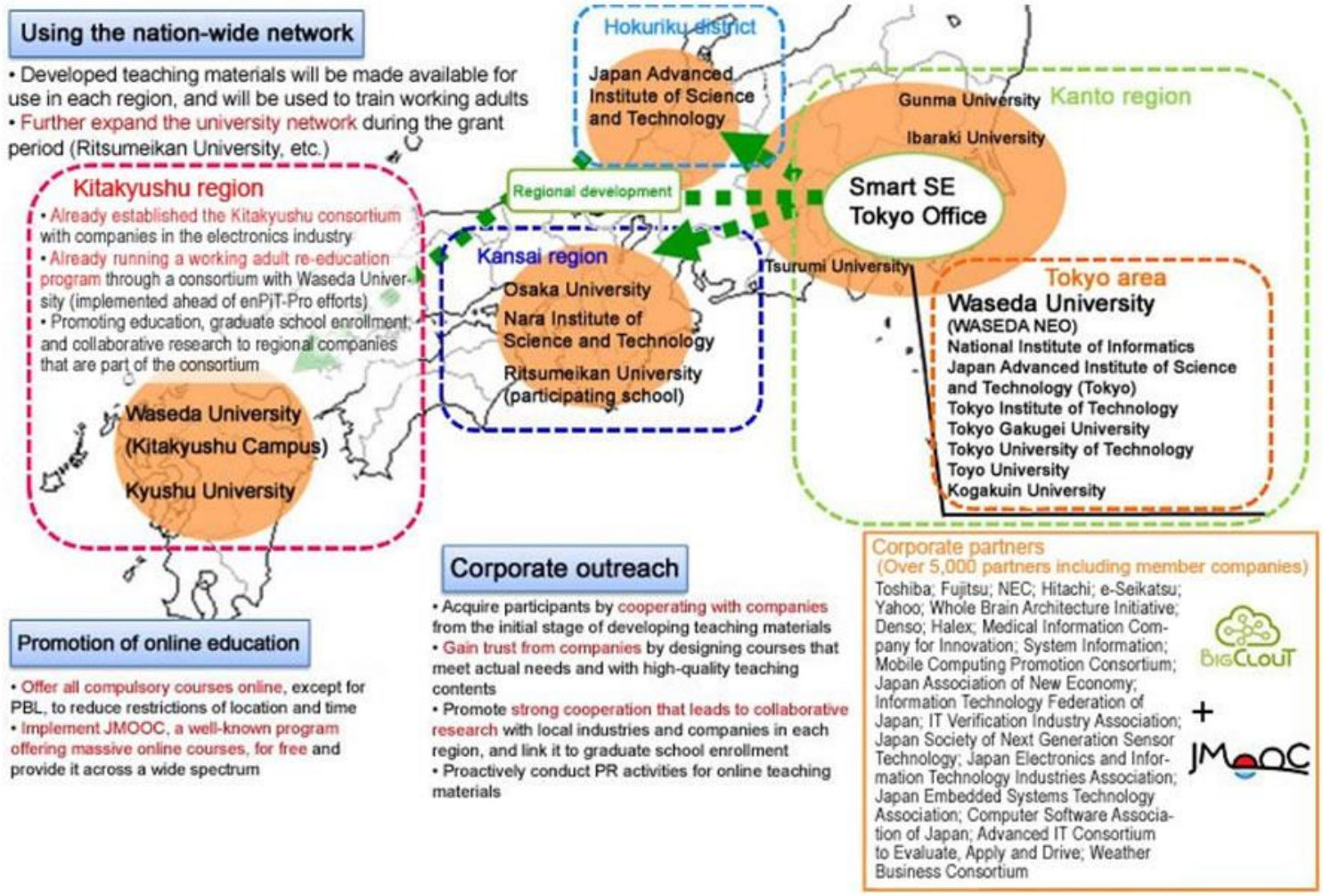


Human resources who will lead the creation of value through the provision of smart systems and services: Full-stack engineers with expertise (three types)

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



# Industry-academia collaboration network



# Agenda

- Overview of SmartSE
- Practical features in SmartSE
  - Comprehensive program sets
  - Quality assurance
  - Feedback loop of education and research
- Related activities in IEEE-CS PEAB

# 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

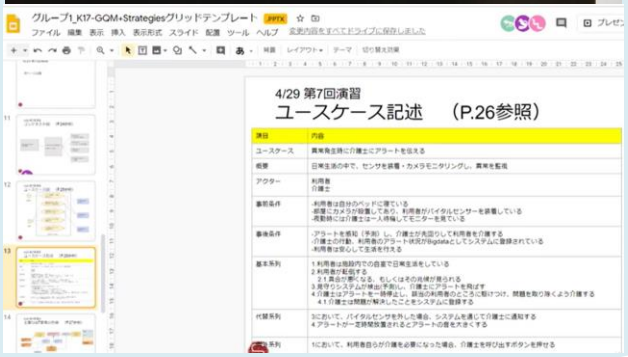
# 1. Blended learning

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

ONLINE REAL

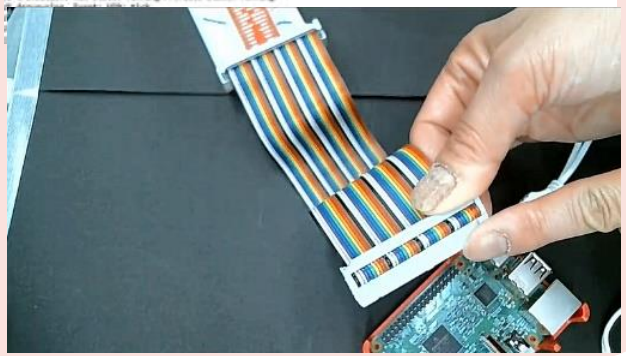
## Group work without devices

- 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

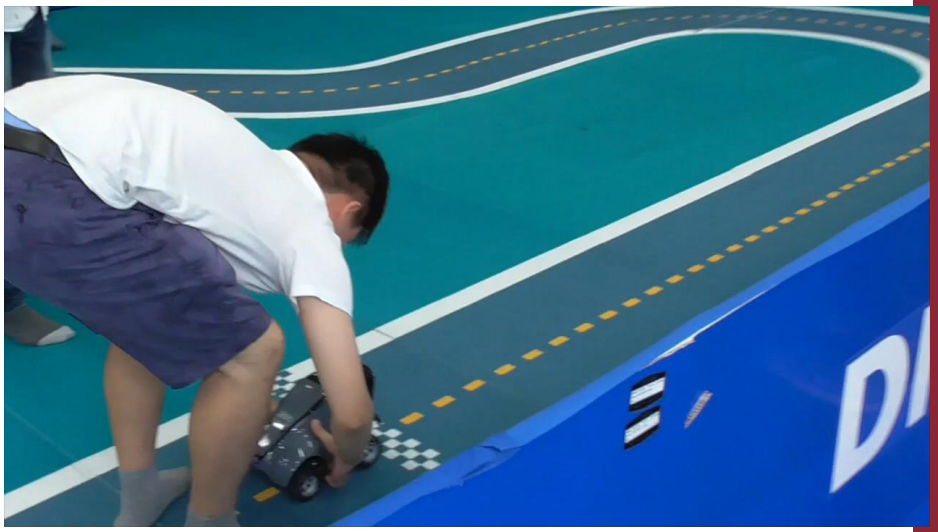
edX

- 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 | Partial | JMOOC/gacco | edX |
|---|---|---|---|---|
| **Lecture courses** | 15 courses and 3 projects | 8 courses | 13 courses | 1 course |
| **Learning methods** | Live-stream, on-demand, assembly format | Live-stream, on-demand | On-demand only, no exercise | On-demand only, no exercise |
| **Duration** | 6 hours/week | 6 hours/week | 3 hours/week | 3-5 hours/week |
| **Course periods** | 6 months | 4 months | 3 months | 2 months |
| **Capacity** | 30 learners | 50 learners | No limit | No limit |
| **Fee** | Approx. 5,000USD | Approx. 3,200USD | Free | Free (99USD for certificate) |

# 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

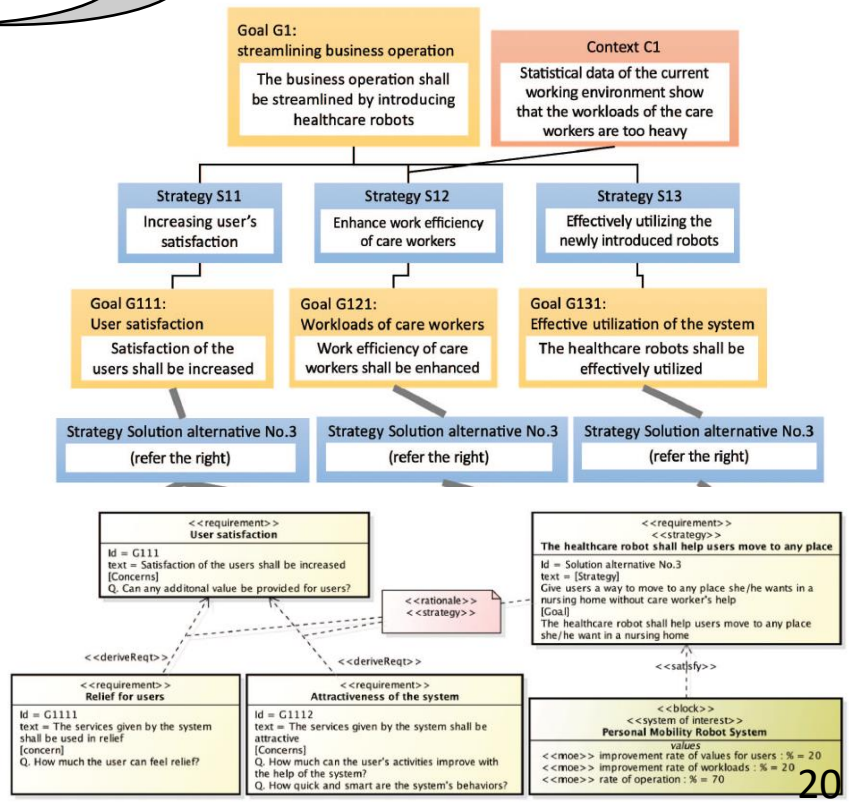
- Identifying strength and weakness (and potential extension) of the program
- Reference frameworks
  - Bodies of Knowledge: SWEBOK, INCOSE SE Handbook, PMBOK, …
  - Skill framework: SFIA framework, e-CF, …
  - Competency framework: **i Competency Dictionary (iCD)**, SWECOM, …

| | Skill a | Skill b | … | Competency x | Competency y | … |
|---|---|---|---|---|---|---|
| Course 1 | X | | | X | | |
| Course 2 | | X | | X | X | |
| … | | | | | | |
| Course N | X | | | | X | |

# 3. Feedback loop of education and research

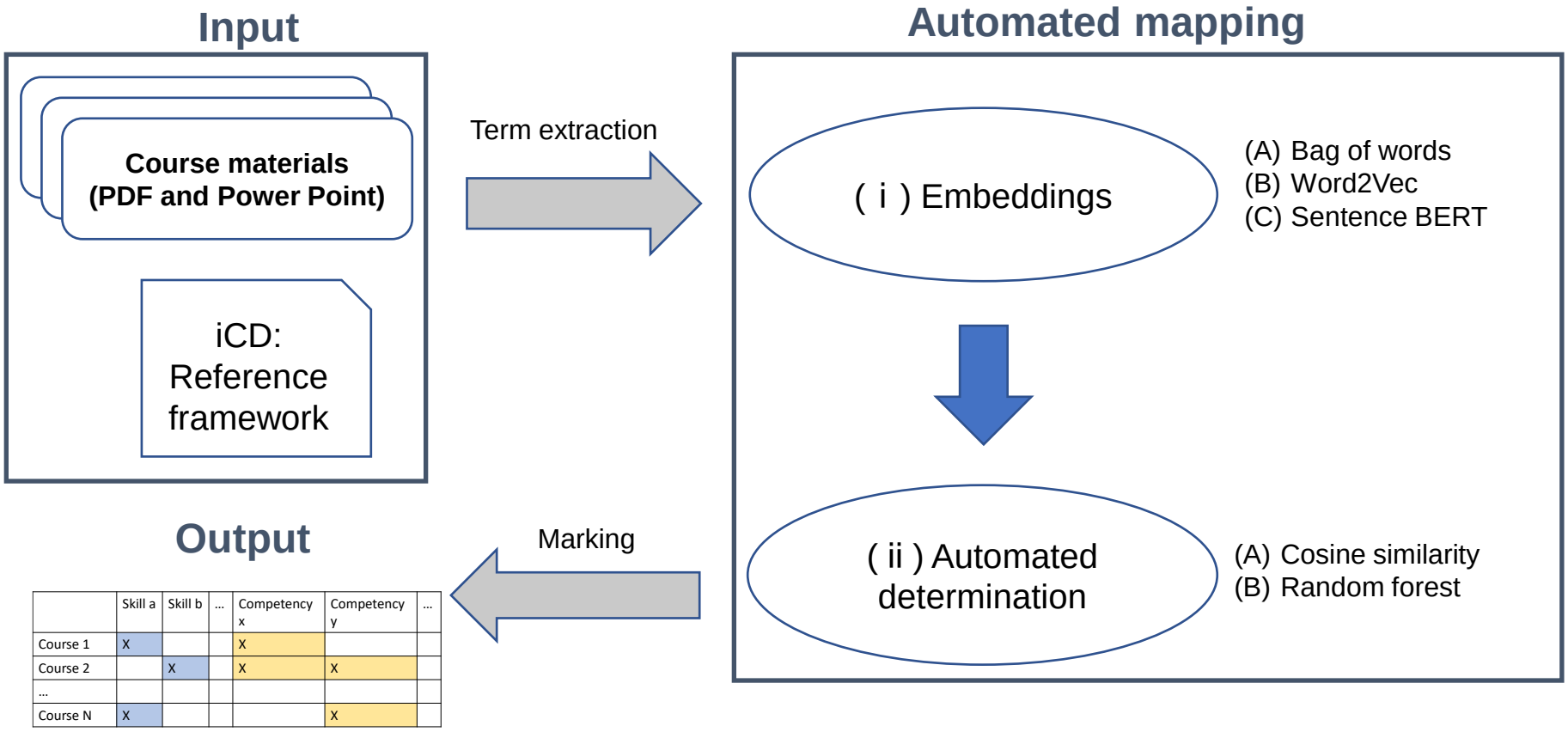
## Education
- Identifying potential problems
- E.g., IoT systems involving IoT business and systems modeling

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




- A case study of applying GQM+Strategies with SysML for IoT application system development, EAIS 2019
- Horizontal Relation Identification Method to Handle Misalignment of Goals and Strategies Across Organizational Units, IEEE Access 7(1), 2019
- Continuous modeling supports from business analysis to systems engineering in IoT development, EAIS 2020
- Systematical Alignment of Business Requirements and System Functions by Linking GQM+Strategies and SysML, Int. J. Service and Knowledge Management 5(1), 2021

# 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 | |

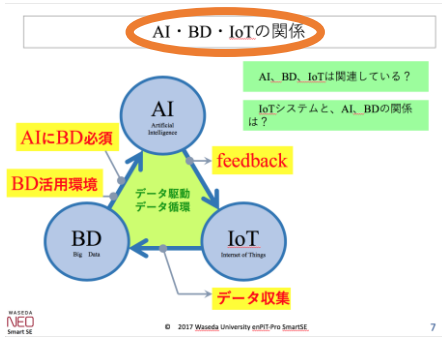
**Mapping result based on frameworks**

"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

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 |

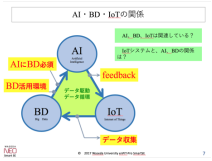
0.92345

0.65689

Lecture courses

- Course 1
- Course 2
- .
- .
- .

## (B) Random forest




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

Text and slides

Manual mapping results

Training data

Explanatory

Feature vector

Objective

Multi-label

Training

Predictor

"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

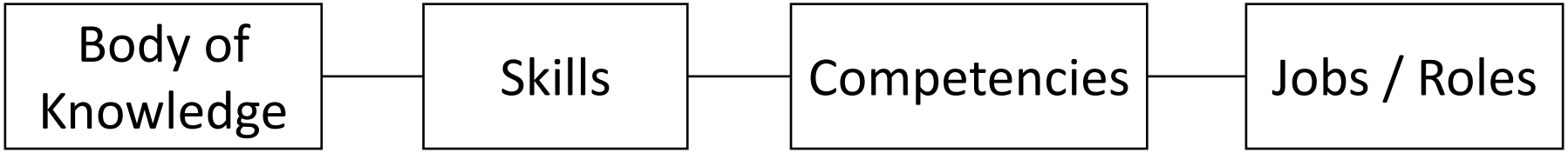
| | Cosine similarity | Supervised learning (BoW) | Supervised learning (distributed representation) |
|---|---|---|---|
| Precision | 0.313 | 0.545 | 0.706 |
| Recall | 0.417 | 0.240 | 0.480 |
| F-value | 0.357 | 0.333 | 0.571 |

"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

# Agenda

- Overview of SmartSE
- Practical features in SmartSE
  - Comprehensive program sets
  - Quality assurance
  - Feedback loop of education and research
- Related activities in IEEE-CS PEAB

# 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

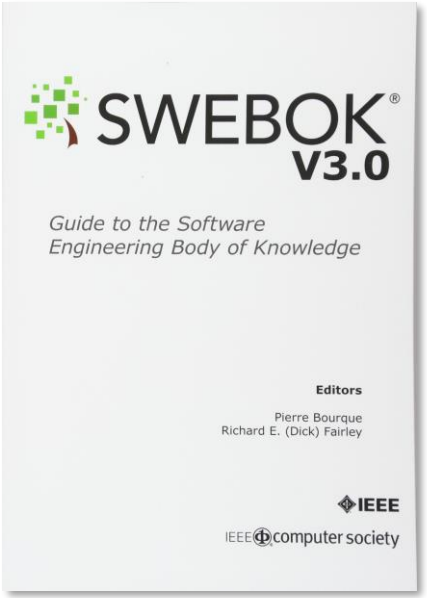
# IEEE Computer Society PEAB - Professional & Educational Activities Board

- 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 2021
- 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



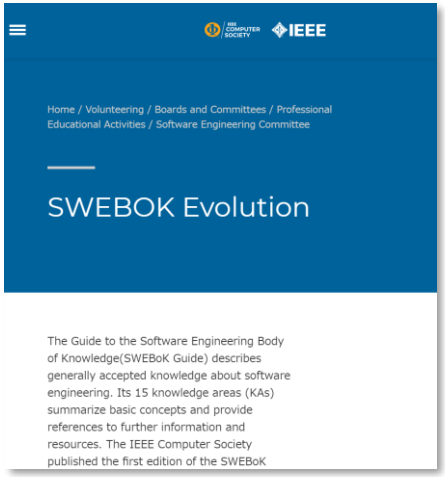
# SWEBOK V3 → V4

- Requirements
- Design
- Construction
- Testing
- Maintenance
- Configuration Management
- Management
- Process
- Models
- Quality
- Professional Practice
- Economics
- Computing Foundations
- Mathematical Foundations
- Engineering Foundations

- Requirements
- **Architecture**
- **Design**
- Construction
- Testing
- **Operation and Maintenance**
- Configuration Management
- **Management**
- **Process**
- Models
- **Quality**
- **Security**
- Professional Practice
- **Economics**
- **Foundations**

# SWEBOK V4 development

- 2020 Achievement
  - Draft list of knowledge areas incl. new ones: Architecture KA and Security KA
  - Major enhancement areas: Economics KA (about value proposition), Maintenance KA (about operation), Engineering Models KA (about agile/DevOps)
  - Major reorganization areas: Computing/Mathematical/Engineering Foundation KAs (incl. connection with AI and IoT)
  - Policy of inclusion: “generally accepted” and “generally recognized”
- 2021 Plan (subject to change)
  - Apr-June: Having revised guideline, Drafting list of topics, and recommended readings, identification of reviewers
  - July-Sep: Drafting topics, reference materials
  - Oct-Nov: Internal review and revising topics
  - Dec-Jan: Public review
  - Feb-Mar: Review comment disposition and release of V4




https://www.computer.org/volunteering/boards-and-committees/professional-educational-activities/software-engineering-committee/swebok-evolution

# Summary

- Smart SE: Recurrent Education Program of IoT and AI for Business
  - 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/en/
- 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.