Linking agro-industrial engineering body of knowledge with industry 4.0: A case study of agro-industrial engineering study program at IPB University

T Djatna
Graduate and Post Graduate Program of Agro-industrial Engineering Study Program-IPB University, Bogor, Indonesia, 16680

Email: taufikdjatna@apps.ipb.ac.id

Abstract. The emergence of Industry 4.0 paradigms has been forcing and changing the landscape aspect of engineering education, as seen in agro-industrial engineering body of knowledge (AIE-BoK). These paradigms push to adapt and to prepare a new approach for curriculum content and delivery. It is urgent to re-think and redefine how to prepare a newer perspective into the three combined disciplines that form AIE-BoK, namely Industrial and system engineering, process/bioprocess engineering, and industrial environmental engineering. They should clearly intertwine their relevance in parallel with pillars of the industry 4.0. These stakeholder’s requirements are the main motivation of this work. Within Industry 4.0 vision, AIE-BoK is investigated on how disruptive technologies play a role in changes. Some issues related to how to utilize common connectivity in technology advancement and to push a relevant curriculum both content and structure are discussed. In order to construct a new map and landscape of curriculum relevancy, it continues with the discussion of how and where agro-industrial engineering education attempts to interpret new roles in industrial revolution 4.0. Along with the consideration of how this interpretation potentially changes agro-industrial products, services, and manufacturing. In closing, a discussion of how agro-industrial engineering curriculum should respond is briefly discussed.

1. Introduction
Within the dictionary of Merriam-Webster [1], a body of knowledge – BoK- defined as the complete set of concepts, terms, and activities that make up a professional domain, as defined by the relevant learned society or professional association. The IIESE (2016) [2] defines the industrial engineering body of knowledge (IEBoK) is composed of 12 knowledge areas. Each knowledge area is represented by an outline that defines what requires to be known to achieve mastery in the field of industrial engineering (IE). A list of references is included in each knowledge area providing a resource to the requisite detail as necessary to obtain a mastery of the areas. As basically provided in the conventional Industrial Engineering Body of Knowledge (IEBoK) which consisted of: 1) Operations research and analysis; 2) Engineering economic analysis; 3) Facilities engineering and energy management; 4) Quality and reliability engineering; 5) Ergonomics and human factors; 6) Operations engineering and management; 7) Supply chain engineering and management; 8) Engineering management; 9) Safety; 10) Information engineering; 11) Design and manufacturing engineering; 12) Product design and development; 13) System design and engineering. Furthermore, in case of AIE-BoK, the ABET program criteria for
The discipline of Agro-industrial Engineering in IPB University, initially conceived from the Department of Agricultural Product Technology in 1981, with the core idea of added-value engineering to agricultural products. From the beginning of its appearance, engineering aspect both in the industrial management system and process-bioprocess engineering are the main characteristics of this department. The later discipline added was industrial environmental engineering and management to sum up the whole process engineering of agro-industrial technology with the sustainability aspect. A series of workshops led by the global requirement for engineering compatibility have made a crucial rebranding from technology into engineering in 2017, after 36 years of the technology-based curriculum.

In these changes, starting 2018, as a study program under agro-industrial technology, Agro-industrial Engineering Knowledge of Body (AIE-BoK) set as the intertwined discipline stream of industrial system engineering, process-bioprocess engineering and industrial environment engineering and management. As effort to align with engineering education, the learning outcomes of this study program are able to (1) Identify, analyze, solve engineering problem of agro-industry, cover up to system, process, management, and environmental engineering through application of mathematical, engineering and information science by using modern tools; (2) Design agro-industrial system/components, process and products to fulfill requirement in a realistic constraints; (3) design and conduct scientific and engineering research, analyze and to interpret collected data; (4) Realize the importance to participate in long-life learning; (5) Communicate effectively both in written and oral; (6) Take role effectively in multi-discipline and multicultural teamwork; (7) Comprehend ethics and professional application in solving agro-industrial engineering with context of economics, environment, community as well as other contemporary issues; (8) Transform idea based on mathematics, IT, Natural Science and Technology (MINT) into techno-entrepreneur of agro-industrial business.

It is our ultimate aim to educate outstanding engineers who will contribute and grow with the digitalized world of agro-industrial products and services in the future. In this work, we introduce a curriculum mapping consisting of a pillar describing the changes/enhancements to be conducted in the areas of curriculum development concepts. We also report our current application of this map at IPB University, Indonesia. This pillar is the implementation of the Industry 4.0 concept in the curriculum of agro-industrial engineering departments, which reveals synergistic benefits of different expertise areas and helps the application and improvement of Industry 4.0 concept in numerous areas.

The goal of this work is to present a generic map to link engineering education to the requirements of Industry 4.0 by specifying needed changes to the curriculum content. The rest of the article is organized as follows. Section 2 gives an account of the recent research on education in the Industry 4.0 context. Section 3 presents a generic method that was used to transform engineering education at the IPB University, particularly in Agro-Industrial Engineering Department according to the requirements of future Industry 4.0 production environments. Section 4 presents how the link of interpretation based on digital processes required in Industry 4.0. Next in Section 5 elaborates on the implication of Industry 4.0 for agro-industrial engineering curriculum. Finally, in Section 6, we discuss our conclusion and recommending remarks.

2. Literature review

2.1. Industrial revolution 4.0 (IR 4.0)

The term Industry 4.0 stands for the fourth industrial revolution Industry 4.0 is originally a future vision described in the high-tech strategy of the German government that is conceived upon information and communication technologies like Cyber-Physical Systems, Internet of Things, Physical Internet, and Internet of Services to achieve a high degree of flexibility in production (individualized mass production), higher productivity rates through real-time monitoring and diagnosis, and a lower wastage
rate of material in production. In addition, it is defined as a new level of organization and control over the entire value chain of the life cycle of products; it is geared towards increasingly individualized customer requirements. Industry 4.0 is a realistic concept that includes concerns about the strict integration of humans in the manufacturing process to have continuous improvement and focus on value-added activities and avoiding wastes [3]. Industry 4.0 has been defined as: "a collective term for technologies and concepts of value chain organization which draws together Cyber-Physical Systems, the Internet of Things, and the Internet of Services". In Industry 4.0, cyber-physical systems made up of connected systems of software, sensors, machines, workpieces, and communication technologies monitor physical processes, create a virtual copy of the physical world, and make decentralized decisions. This is all done while communicating with one another, with humans, and with centralized controllers in real-time as products travel through the production system. Over the industrial Internet of Things. These devices interact with decentralized analytics to enable decision-making and real-time responses such as predicting failure, self-configuration, and adapting to changes. Via the Internet of Services, both internal and cross-organizational services are offered and used. Industry Revolution 4.0 (IR 4.0) affects AIE education and curriculum of a major current worldwide trend and the identification of curriculum content enhancements necessary to accommodate Industry 4.0 concerns. Industry 4.0 marks a major new period in the world industry, particularly manufacturing. An emerging challenge is the ability to develop a framework for clarifying the roles of IEs in an Industry 4.0 environment.

In addition, it is necessary to identify the potential curriculum reforms that would prepare and give AIEs sufficient knowledge so that they can function effectively in Industry 4.0 systems, as well as in traditional organizations. Research methods include a literature review, a study of AIE curricula, and a questionnaire survey of AIE programs. It indicates that several AIE functions become somewhat transformed, less visible, or downright diminished in Industry 4.0. Emphasis has shifted from traditional AIE methods to data-driven functions and cyber-physical systems. The developing mismatch needs correcting by emphasizing skills such as 'big data' analytics and novel human-machine interfaces in AIE curricula. In the last part, the authors propose a set of curriculum enrichment items as the basis for reform and it creates a need to reassess the role and position of AIEs curriculum relevance to IR 4.0.

2.2. Industrial engineering education interpretations of industrial revolutions 4.0

Ghobakhloo (2018) depicts twelve design principles and 14 dependent technology trend lever in Industry 4.0 as illustrated in figure 1 [4]. Key design principle of an Industry 4.0 system include a modularity structure for increased flexibility; interoperability, whereby entities communicate seamlessly with each other; virtualization, with a strong emphasis on simulation and decentralized decision-making; real-time capability for the fast response; and a service orientation that gives customers virtual guidance for self-service.

Industry 4.0 is the vision of the industrial process in the future, according to Boston Consulting Group (2015) there are nine pillar of IR 4.0, namely (1) Big data and analytics (2) Augmented reality (3) Additive manufacturing (4) The cloud (5) Cybersecurity (6) The industrial Internet of Things (7) Horizontal and vertical system integration (8) Simulation (9) Autonomous robots [5]. One important impact of the advance of communication systems is connected to society, where all resources for learning are open with all ubiquitous characteristics (anywhere, anytime, anyone). In such a condition, knowledge is not only transferred traditionally but nowadays the learning process provides optimizing self-potential within student community. Learning process must provide greater space for the student for utilizing and developing in terms of personalized, flexibility and lifelong learning. Moreover, advances in information technology have made life an ecosystem. Over the past few years, the world is facing the fourth industrial revolution. The working environment is demanded to be changed, rapidly, with the hope that it will bring significant benefits in the future.
Usual manufacturing processes are being automatized and connected to other activities within the company. One of the most important factors in Industry 4.0 environment is data management, big data management to be correct. It is done with the use of cyber-physical systems (CPS), internet of things (IoT) and cloud computing. Human professions are obligated to adapt and change so the roles that are known are suggested to get a different structure in the future. Workers have to learn to deal with the new situation and accept the term of life-learning process, constantly improving their performance. In the end, with the use of both technological and human improvements, bigger productivity, product quality and income with lower product delivery (manufacturing) time and product price are expected. Apart from that, the term mass customization has become very important and that demands very flexible manufacturing. Industry 4.0 holds the promise of increased flexibility in manufacturing, along with mass customization, better quality, and improved productivity. It thus enables companies to cope with the challenges of producing increasingly individualized products within a short lead-time to market and higher quality. Intelligent manufacturing plays an important role in Industry 4.0. Typical resources are converted into intelligent objects so that they are able to sense, act, and behave within a smart environment. In order to fully understand intelligent manufacturing in the context of Industry 4.0 with associated topics such as intelligent manufacturing, Internet of Things (IoT) -enabled manufacturing, and cloud manufacturing together with key technologies such as the IoT, cyber-physical systems (CPSs), cloud computing, big data analytics (BDA), and information and communications technology (ICT) that are used to enable intelligent manufacturing. They are all potentially enrich all three streams where AIE-BoK works. Digitization and intelligentization of manufacturing process is the need for today’s industry. The manufacturing industries are currently changing from mass production to customized production. The
rapid advancements in manufacturing technologies and applications in the industries help in increasing productivity.

2.3. Disruptive technologies in industry 4.0
Disruptive innovations are innovations that are inferior to, or which underperform available market solutions. The terms of "inferior" or "underperform," not literally mean lower quality (although that may be the way in which the disruptor is inferior) or performance as it is often thought of in terms of “power” (for example, the engine has greater horsepower and torque than engine. Instead, these terms are relative to attributes that customer's value in the existing product alternatives. In addition to disruptive technology, which conforms to four criteria, they are cheaper, simple, smaller and more convenient than the rival, incumbent technologies they frequently displace as market leaders [6]. The appearance of such technologies of disruptive innovation gets different responses such as pessimism.

2.4. Emerging skills requirements
With the changes in operational and agro-industrial, technologies are reshaping the manner in which manufacturers produce goods in all industries. These changes, referred to as Industry 4.0, are hallmarked by the employment of big data, advanced analytics, human-machine interfaces, and the digital to the physical transformation process in manufacturing [7]. For manufacturers, Industry 4.0 presents productive opportunities by ushering in new operational technologies and allowing for enhanced implementation of transformative in agile cultures [8]. In addition to enabling manufacturing productivity, Industry 4.0 has enabled manufacturers to digitize information across their enterprise. The World Economic Forum (2018) depicts a rapid shift in the types of skills needed for domestic manufacturers to remain competitive in an equally rapidly changing market [9]. Emerging skills in analytical thinking, creativity, complex problem solving, and emotional intelligence are of increasing importance for today’s economy. In response, domestic companies are not only looking to Industry 4.0 for solutions but also to effective workforce development strategies to reskill the incumbent workforce.

3. Methodology
To fulfill this target, a two-part data collection process was followed: a literature study carried out to review publications relevant to the aim, and a curriculum data collection relevant for AEI-BoK. The outcome of the literature search was an initial set of findings that were later combined with data from the other sources to form the final conclusions and basis for determining the requirement for enriching the AIE curriculum.

The research framework consists of a curriculum pillar based on AIE-BoK. The pillar contents in the form of courses derived from three streams, which are interrelated and even dependent on each other. Furthermore, they are compared to ideas developed in Industry 4.0 technologies. Related method such as clustering ideas of Industry 4.0 was deployed to investigate the opportunity to apply. Mapping these ideas in Industry 4.0 paradigms then combine with scientific research including developed ideas and prototyping courses running at Agro-Industrial Engineering Department (AIE) -IPB University, both compulsory and elective courses.

4. Interpretations based on digital processes required in industry 4.0
Interpretations of Industry 4.0 based on organizations’ functions of the curriculum is based on how decision/strategy deployments. With the above literature studies and their related discussion, it is a huge number of data available to decide. As a fact, data is nothing without actions, actions require insights. The following figure 2 illustrates how each pillar from Boston Consulting Group [5] can be as strengthening the learning foundations to cope with the rapid changes as in liberal Arts, design thinking, system thinking, and life long learning. Another section as called a cluster of cyber physical systems which consisted of an advanced manufacturing system, advanced materials, autonomous system and smart connected sensors. Another cluster is called a data engineering concept and application. This cluster consisted of the internet of things, with paradigms of big data and analytics, use the cybersecurity
operation within cloud computing. One of the important issues dealing with agro-industrial engineering within is logistics 4.0 as vertical integration that potentially combined with Artificial intelligence (AI) and mobile wearable device. Some components of this cluster may be in future consent of AIE-BoK to apply, but most of them are reliable to include and embed into the newer curriculum of AIE-BoK.

Figure 2. The clusters of components of Industry 4.0 pillars.

5. Implications of industry 4.0 for agro-industrial engineering curriculum

Some questions arise with what are possible new areas of knowledge or competence in an Industry 4.0 environment. For this inquiry, AIEs have to be exposed to in order to function effectively in their fundamental role as productivity champions? At the very least, the above questions were intended to address the overarching question on how to adequately produce engineers able to function effectively in Industry 4.0 systems. Beyond guiding the literature search, the above question fed into an institution data collection process, with the specific secondary questions having evolved from the outcomes of the former exercise, where is agro-industrial engineering education interpretations of industrial revolutions 4.0.

In the following table 1 describes the near future industry 4.0 influence of AIE-BoK. According to figure 2 previously illustrated, each newly revised curriculum is mapped with the prospect and relevant pillar of Industry 4.0 [5]. As provided in table 1, most, of course, both compulsory and elective assigned with the capabilities of design and system thinking in liberal arts cluster. Some courses which derived from a stream of industrial system engineering assigned with the capabilities of cyber physical system within their learning objective setting. There are courses of system analysis and decision making, Logistics and supply chain systems, autonomous process control and agro-industrial management information system.

From the internal discussion, it is necessary to enhance legacy courses from both stream of process and bioprocess engineering and industrial environmental engineering and management. As shown in table 1, most of the courses derived from this stream are mapped into analysis for insight. It is indicated that the content and learning objective of those courses potentially enriched with applied industry pillars such as sensors and data mining to grab a further understanding of the course. Currently, most of the courses are carried out for conventional engineering approaches.
| No | Compulsory Agro-Industrial Engineering Courses | Credit | Libera l Arts | Data Engin eering | Analysi s for Insight | Conne ctivity /Intera ction | Cyber Physic al Syste m |
|----|-----------------------------------------------|--------|---------------|------------------|----------------------|---------------------------|-----------------------|
| 1  | AGB100 Introductory to Entrepreneur            | 1(1-0) | ✓              |                   |                      |                           |                       |
| 2  | TMB208 Engineering Drawing                    | 3(2-3) |               |                   |                      |                           |                       |
| 3  | TIN100 Introductory to Agro-Industry          | 2(2-0) | ✓              |                   |                      |                           |                       |
| 4  | TIN212 Human Resource Development              | 2(2-0) |               |                   |                      |                           |                       |
| 5  | TIN214 Information and Computational Technology | 2(1-2) | ✓              | ✓                 | ✓                    | ✓                         | ✓                     |
| 6  | TIN215 Mathematics                             | 3(2-2) | ✓              |                   |                      |                           |                       |
| 7  | TIN216 Industrial Statistics I                 | 3(2-2) |               |                   |                      |                           |                       |
| 8  | TIN220 Fundamental of Process Engineering      | 3(2-3) |               |                   |                      |                           | ✓                     |
| 9  | TIN233 Industrial Microbiology                 | 2(2-0) |               |                   |                      |                           | ✓                     |
| 10 | TIN251 Agricultural Product Material Science  | 2(2-0) |               |                   |                      |                           | ✓                     |
| 11 | TIN252 Agro-industrial Material Analysis       | 1(0-3) |               |                   |                      |                           | ✓                     |
| 12 | TIN211 Work Methods                            | 2(2-0) |               |                   |                      |                           |                       |
| 13 | TIN217 Algorithms and Computer Programming     | 3(2-3) | ✓              | ✓                 | ✓                    | ✓                         | ✓                     |
| 14 | TIN222 Operation Units                         | 3(2-2) |               |                   |                      |                           |                       |
| 15 | TIN224 Process Units                           | 2(2-0) |               |                   |                      |                           | ✓                     |
| 16 | TIN230 Fundamental of Bioprocess Engineering   | 2(2-0) |               |                   |                      |                           | ✓                     |
| 17 | TIN234 Bioprocess Labs                         | 2(0-6) |               |                   |                      |                           |                       |
| 18 | TIN242 Packaging Technology                    | 3(2-3) | ✓              |                   | ✓                    |                           | ✓                     |
| 19 | TIN253 Agro-industrial Product Science         | 2(2-0) |               |                   |                      |                           | ✓                     |
| 20 | TIN254 Agro-industrial Product Analysis        | 1(0-3) |               |                   |                      |                           | ✓                     |
| 21 | TIN310 Plant Layout and Material Handling      | 3(2-3) | ✓              | ✓                 | ✓                    | ✓                         | ✓                     |
| 22 | TIN311 Operations Research                     | 3(2-3) | ✓              |                   |                      |                           |                       |
| 23 | TIN318 Cost Engineering                        | 3(3-0) | ✓              | ✓                 | ✓                    | ✓                         | ✓                     |
| 24 | TIN326 Industrial Equipment and Machinery      | 3(2-3) |               |                   |                      |                           | ✓                     |
| 25 | TIN351 Quality Engineering                     | 2(2-0) | ✓              |                   |                      |                           |                       |
| 26 | TIN360 Management                              | 2(2-0) |               |                   |                      |                           |                       |
| 27 | TIN362 Environment Laboratory                  | 1(0-3) | ✓              |                   |                      |                           | ✓                     |
| 28 | TIN370 Innovation of Agroindustrial Product & Business | 3(2-3) | ✓              |                   |                      |                           | ✓                     |
| 29 | TIN312 Production Planning and Inventory Control | 3(2-3) |               |                   |                      |                           | ✓                     |
| 30 | TIN316 System Analysis & Decision Making       | 3(2-3) | ✓              | ✓                 | ✓                    | ✓                         | ✓                     |
| 31 | TIN319 Industrial Statistics II                | 3(2-3) | ✓              |                   |                      |                           | ✓                     |
| 32 | TIN327 Plant Design                            | 3(2-3) | ✓              |                   |                      |                           | ✓                     |
| 33 | TIN340 Storage and Warehousing Technology      | 3(2-3) |               |                   |                      |                           | ✓                     |
| 34 | TIN361 Industrial Waste Control Technology     | 3(2-3) | ✓              |                   |                      |                           | ✓                     |
| 35 | TIN410 Modelling and Process Optimization Technique | 3(2-2) |               |                   |                      |                           | ✓                     |
| No. | Compulsory Agro-Industrial Engineering Courses | Credit | Libera l Arts | Data Engin eering | Analys i s for Insight | Conne ctivity /Intera ction | Cyber Physical Syste m |
|-----|-----------------------------------------------|--------|---------------|------------------|-----------------------|--------------------------|----------------------|
| 36  | TIN461 Occupation Health and Safety            | 2(2-0) |               |                  |                       |                          |                      |
| 37  | TIN470 Project and Industrial Design          | 3(1-6) | ✓             |                  |                       |                          |                      |
| 38  | TIN497 Methods of Scientific Writing and Presentation | 1(1-0) |               |                  |                       |                          |                      |
| 39  | TIN496 Colloquium                            | 1(0-2) |               |                  |                       |                          | ✓                    |
| 40  | FTP402 Communal Thematic Internship          | 3(0-3) |               |                  |                       |                          |                      |
| 41  | FTP400 Industrial Internship                 | 2(0-6) |               |                  |                       |                          |                      |
| 42  | TIN498 Seminar                               | 1      | ✓             |                  |                       |                          |                      |
| 43  | TIN499 Final Project                         | 6      | ✓             |                  | ✓                     | ✓                       |                      |

**Elective Courses**

| No. | Code | Course                                                                 | Credit | Libera l Arts | Data Engin eering | Analys i s for Insight | Conne ctivity /Intera ction | Cyber Physical Syste m |
|-----|------|------------------------------------------------------------------------|--------|---------------|------------------|-----------------------|--------------------------|----------------------|
| 1   | TIN31A | Stochastic Quantitative Method                                       | 3(2-2) |               |                  | ✓                     | ✓                       |                      |
| 2   | TIN31B | Logistics & Supply chains System                                      | 3(2-2) | ✓             |                  | ✓                     | ✓                       |                      |
| 3   | TIN328 | Starch, Sugar and Sucro-chemical Processing                           | 3(2-3) |               |                  |                       |                          |                      |
| 4   | TIN329 | Oil and Fat Technology                                                 | 3(2-3) | ✓             |                  |                       |                          |                      |
| 5   | TIN341 | Packaging for Distribution & Transportation                           | 3(2-3) |               |                  |                       |                          |                      |
| 6   | TIN363 | Cleaner Production                                                     | 3(2-3) | ✓             |                  | ✓                     | ✓                       |                      |
| 7   | TIN411 | Autonomous Process Control                                            | 3(2-3) |               |                  |                       | ✓                       |                      |
| 8   | TIN412 | Agro-Industrial Management Information System                         | 3(2-3) | ✓             |                  | ✓                     | ✓                       | ✓                    |
| 9   | TIN424 | Essential Oils and Phyto-Farmaca Processing                            | 3(2-3) |               |                  |                       | ✓                       |                      |
| 10  | TIN425 | Refresher and Horticultural Processing                                | 3(2-3) |               |                  |                       |                          |                      |
| 11  | TIN426 | Rubber, Fibre & Gum Processing                                         | 3(2-3) |               |                  |                       |                          |                      |
| 12  | TIN427 | Skin and Hide Processing Technology                                    | 3(2-3) | ✓             |                  |                       |                          |                      |
| 13  | TIN430 | Bio industrial Process Engineering                                     | 3(2-3) |               |                  |                       |                          |                      |
| 14  | TIN440 | Active and Smart Packaging                                            | 3(2-3) |               |                  |                       | ✓                       |                      |
| 15  | TIN462 | Liquid Waste Handling and Engineering                                  | 3(2-3) | ✓             |                  |                       | ✓                       |                      |
| 16  | TIN463 | Solid Waste Handling and Engineering                                   | 3(2-3) |               |                  |                       | ✓                       |                      |
| 17  | TIN464 | Air Pollutant and Waste Control and Engineering                        | 3(2-3) |               |                  |                       | ✓                       |                      |

Important changes have made so far show with the additional computer programming courses in compulsory and more IT-based courses offered as elective. The entry programming course for AIE is now not only a mere programming course, but also an introductory course into information and computational technology to provide students not only high-level programming languages, but also new programming languages that are common for engineering communities like Visual Basic for Application with the skill of spreadsheet computation combined with statistical tools such as Minitab or SPSS. In the following term, programming skills of AIE students are to be improved in object-oriented programming in a more common in artificial intelligence and data science contents by using Python.
programming. As an introduction to software engineering project for students is conceived in order to enable the students to define and work on the same project. In the next term student are provided with system analysis and decision making capabilities. Main aspect of this course is to constructing business process modelling and multi attribute system integration. As a cross-program course, this course requires the collaboration of lecturers from different engineering programs, so that the students can create project teams containing students from different disciplines. In that way, it is possible to realize projects that are much more realistic and interesting. Also, a better organization of teamwork is effectively enabled, since the division of work can now be done having team members already coming from different disciplines. This is one of the key changes to the curricula of the engineering programs to adapt them to Industry 4.0, since the projects related to Industry 4.0 virtually always need to be implemented in an interdisciplinary manner.

Other relatively common courses are industrial statistics I & II. Both of these courses impart also key competences to the students in regard to Industry 4.0. These both courses in statistical methods should lay foundations for the understanding of subjects like machine learning and artificial intelligence. In an Industry 4.0 manufacturing environment, a tremendous amount of data flow occurs between production resources and cloud systems.

In our opinion according to the mapping in table 1, syllabi of all courses in form of learning plan of a semester/digital learning plan (RPS/RPD) should be modified as available mapping in the table 1 to ensure alignment with industry 4.0 vision. Furthermore IPB University should also evaluate the whole contents of MOOC (Massive Online Open Course) right before application of online-digital e-learning dictate for the partial or whole mode of learning process.

6. Conclusion and recommending remarks
In this work, we proposed how to link agro-industrial engineering body of knowledge with Industry 4.0 based on our experience in undergraduate study program of Agro-industrial engineering at IPB University. In changing the curriculum components, we determined which cluster of pillars in Industry 4.0 may have relevance with courses content which already offered under AIE-BoK. From tabulation of Industry 4.0 vision on both compulsory and elective course shown that majority of courses derived from stream of Industrial system engineering have been reinforced with artificial intelligence and data science contents. Legacy courses from stream of process-bioprocess engineering and industrial environmental engineering and management need more internalization effort to align with vision and pillars of Industry 4.0. In order to cope the whole AIE-BoK linkage to Industry 4.0 vision, this study should extend to improvement of laboratory’s activity modules plus student club components.

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