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Master Degree in Industry 4.0

Ind4.0 (610455-EPP-1-MY-EPPKA2-CBHE-JP)

AGRICULTURE

AUTOMOTIVE

MANUFACTURING

HEALTH

**DELIVERABLE OF ERASMUS+IND4.0 WP2
D2.8 Ind 4.0 Professional/VET Courses
Outline**





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D2.8 Ind 4.0 Professional/VET Courses Outline

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Projection Information

Project Acronym	InD4.0
Project Full Title	Master Degree in Industry 4.0
Project No	601455-EPP-1-2019-1-MY-EPPKA2-CBHE-JP
Funding Scheme	ERASMUS+ KA2 Capacity Building in the field of Higher Education
Coordinator	Universiti Teknologi MARA (UiTM)
Project Website	https://www.ind4-0-eu.my/

Work Package 2 Development of the Ind4.0 MSc Curriculum & VLE

Deliverable: 2.8 Ind 4.0 Professional/VET Courses Outline

Type: Document

Dissemination level: Public

Version: Final

Delivery date: 17/12/2021

Keywords: Didactic model, Content design guidelines, Distance Learning
Quality Assurance

Abstract: This deliverable provides an overview of helpful organisational, assessment, design and teaching approaches, examples of best practices, and practical tips for educators when employing a distance learning model for delivering the MSc in Industry 4.0 programme.

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Date 17/12/2021

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Abstract

The current document constitutes the methodological framework regarding the design and development of the professional training courses within the Ind4.0 project. Each Asian University is set to develop at least 1 new professional training course tailor made to the training needs of the regional industry and special characteristics of its region. A total of 9 new core and 3 new elective professional training courses were created following the input from D1.3 Needs analysis report on relevant.

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1. Professional Course in Industry 4.0 (Ind4.0)- Module Syllabus

Three elective Ind4.0 VET courses are identified with the to provide introductions to three orientation in the manufacturing sector (Manufacturing 4.0), agriculture/aquaculture sector (Agriculture/Aquaculture 4.0) and pervasive health/health sector (Pervasive Health/ Health 4.0). The introductory VET courses will consist of the major components, processes and technologies and how new products and services will impact business and society.

Professionals/VET courses (MOOCs) have been designed for anyone who wish to learn how to address the new challenges in Industry 4.0 (Ind4.0) posed by the ever-increasing globalization in production, manufacturing, and service provision. The certification framework focuses on the 9 core courses on more general IoT components of Ind4.0 and 3 elective courses on the understanding the fundamentals of its application of the Manufacturing, Agriculture/Aquaculture and Health sectors (Table 1). The long-term objective is for IT professionals and company personnel keen to implement Ind4.0 to be able to follow a fast-track upskilling course on IoT.

Table 1: The Professional /VET Courses of Ind4.0

	Course Title/ Lesson	HRS
Core Courses		
1	Cyber security in Industry 4.0	2
2	Networking Technologies and Sensors	2
3	Artificial Intelligence	2
4	Machine Learning and Big Data Analytics	2
5	Cloud Computing Services and Technologies	2
6	Robotics and Industry 4.0	2
7	Digital Transformation and Business Models	2
8	HCI for Industry 4.0	2
9	Sustainable Product Design & Manufacturing	2
Elective Courses		

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10	Process management in Manufacturing 4.0	2
11	Introduction to Agriculture/ Aquaculture 4.0 Ecosystem for Smart Farming	2
12	Introduction to Pervasive Health/Health 4.0	2

The detail professional training course contents are under Work Package 3, therefore, the details of this document are used as guidelines for the VET curricula and the design of the corresponding part of the methodology. The components of the courses were designed made available fully online via a Virtual Learning Environment (VLE) platform specifically designed for the project. The professional courses' profile is targeted at:

- Professionals already working within the industry 4.0 sector.
- Graduates who aim to get in the sector's labour market.

To complete the training of each course successfully, the participants must undertake an assessment with multichoice questions. Each participant will receive a certificate. Certificate from the Ind4.0 Partnership (Figure 1).

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Figure 1 Certificate of Professional/ VET course

2. Basic Concepts when Designing a VET Course

Similarly, to the Master’s Course, in order to design the core material, the Asian HEIs should focus on the following key points:

- Learning Outcomes: What participants (target groups identified in the introduction) will be able to know/do after the completion of each module.
- Training Materials: What training materials need to be developed and what the materials will include, in order to achieving the programme’s goals.
- Training Methods: The methods that will be used so that participants meet the learning objectives and acquire necessary skills and competences.
- Logistics: Where and when the piloting will take place and what type of logistics will be needed.

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The core material of the to-be developed courses focuses on offering different levels of experience and abilities to learners. The curricula will offer flexibility and a personalized learning experience. The learners will be able to be engaged in the training activities regardless of time and location via the VLE. More specifically they will be able to:

- participate from any location.
- participate in multiple concurrent discussions.
- follow asynchronous discussions where participants do not need to be conversing at the same time to participate.

Each module consists of educational material and half an hour of assessment e.g. if a module's indicative hours are 3, it should include 2.5 hours of learning material and half an hour for the assignment). Core material of the course will be consisted of lectures (self-running presentation - power point presentation with or without voice over) and material of any kind for self-study (papers, videos, e-books etc.). The author of each module is free to use any type of lecture (s)he finds more appropriate. The templates should be completed by the authors and revised before the final development of each module. In terms of knowledge the courses offer both theoretical and practical knowledge in specific areas. Special focus should be given to Customer Service and Sales techniques, Communication and Logistics while basic knowledge regarding Legislative and GDPR issues will be acquired.

3. Modularity

The Modular approach ensures students acquiring the needed knowledge in an efficient and cost-effective manner through the Ind4.0 VLE online platform. It consists of a two-phase training process:

Phase 1

The development of the foundational knowledge underlies a specific skill. The aim is to bring all students to the same level of knowledge.

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Phase 2

The performance of the skill can be realized either online (test cases, self-assessments, real work problems) or even in-person training.

Being an approach of flexibility, the existence of mandatory and optional modules is a good practice in organizational trainings.

3.1. Learning Outcomes

“The learning outcomes approach shifts the emphasis from the duration of learning and the institution where it takes place to the actual learning and the knowledge, skills and competences that have been or should be acquired through the learning process” (Cedefop 2013: USING LEARNING OUTCOMES. Learning Opportunities and Qualifications in Europe.

Available at: <https://ec.europa.eu/ploteus/content/descriptors-page>)

Learning outcomes are directly connected to learning assessment as they clearly define what and how is to be assessed. They enable harmonization in assessing the learner’s performance therefore, the learning outcomes affect the process of teaching and learning through assessment. In this understanding the purposes of integrating The development of the learning outcomes is the Bloom’s Taxonomy based on the six levels of objectives.

3.2. The Course Outlines

The course outlines will contain all the course content. The Course sections (Modules/Weeks) will be at the top level of the course and typically represent a time period. A section contains one or more subsections. The Course subsections (Lessons) will be parts of a section, and usually represent a topic or other organizing principle. The Course units will be lessons in a subsection that students view as single pages. A unit can contain one or more components. The Course components will be objects

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within units that contain the actual course content: Videos, reading material, problems/quizzes and discussion forums.

The training materials that can be e.g. video clips / reading material / PowerPoint presentations in the training modules are arranged alternatively with exercise content. This allows learners to find the compactly structured relevant material about a topic more easily without scrolling through a lot of texts or scrubbing through an hour-long video to find the one piece of information they were searching for. This also allows a modular course content or exercise to be easier to change, reorganize, substitute, or enhance because it minimizes the effect on neighbouring material.

3.3. Learning Objects

A learning object is any entity, digital or non-digital, that can be used, re-used or referenced during technology-supported learning, e.g. multimedia content, instructional content, instructional software and software tools that are referenced during technology supported learning. Smaller reusable digital resources include digital pictures or photographs, animation and video clips, small pieces of text, animations and smaller applications available via Web. Bigger reusable digital resources include entire web pages that combine text, pictures and other means, or applications that offer a complete educational experience. A typology of several kinds of learning objects may include:

- Presentation object: Direct instruction and presentation resources designed with the intention to transmit specific subject matter.
- Practice object: Drill and practice with feedback, educational game or representation that allows practice and learning of certain procedures.
- Simulation object: Representation of some real-life system or process
- Conceptual model: Representation of a key concept or related concepts of subject matter
- Information object: Display of information organized and represented with modalities.
- Contextual representation: Data displayed as it emerges from represented authentic scenario.

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3.4. Assessment

Assessment is a process that helps focus attention on what matters most in education, beyond just access and participation: the actual learning outcomes of each student. The Common Quality Assurance Framework (CQAF) for the assessment of the VET courses is adopted as it constitutes a European reference framework to ensure and develop quality in vocational education and training (VET), building on the key principles of the most relevant existing quality assurance models (European Commission 2015). The backbone of the assessment standards is the learning-outcome based approach in designing a training programme. Learning outcomes specify the criteria for success/failure and learners' performance and enable the assessment process to become more transparent and fit for purpose, since learning outcomes define what behaviour is supposed to be assessed. Effective assessment methods put the learner at the centre, are carefully planned and aligned with learning goals.

The templates for developing assessment methods are to ensure standards document as a practical guide for the Asian HEIs, ensuring that the applied assessment methods.

Using different kinds of assessment methods in VLE is in line with the increasingly recognition across European countries.

3.5. Module Syllabus Template

As a first step to the courses' design is the formation of the course outline. A template has been shared to all partners to work on the template a found below:

Table of Contents

1. Module Details
2. Module Description
3. Learning Outcomes
4. Module Knowledge, Skills and Competencies
5. Module Lessons

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6. Practical Assignments
7. Assessment Quiz
8. Assessment Quiz Template 1 “True-False”
9. Assessment Quiz Template 2 “Yes-No”
10. Assessment Quiz Template 3 “Selection of key answers”
11. Assessment Quiz Template 4 “Multiple choice answers”
12. Assessment Quiz Template 5 “Numerical questions”
13. Assessment Quiz Template 1 “Matching questions with sub-answers”

1. Module Details

Module Title	
Credits	
Hours	
N° of hours in presence	
N° of hours in distance learning	
Name of the leading institution	

2. Module Description

3. Learning Outcomes

4. Module Knowledge, Skills and Competencies

5. Modules Lessons

Lesson N.	
Lesson title	
Duration	
Specific objectives	

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Topics	
In presence activity	
Distance learning type of learning object /task	
Other supporting material	

Lesson N.	
Lesson title	
Duration	
Specific objectives	
Topics	
In presence activity	
Distance learning type of learning object /task	
Other supporting material	

Add tables for additional lessons if necessary.

6. Practical Assignment

Practical Assignment Title	
Practical Assignment Code	
Practical Assignment Description	Description of the practical assignments (up to 100 words)
Learning Resource Type	Definition of the learning recourse type for the specific practical assignments (e.g.

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	Example, Case Study, Problem Solving, Text Composition, Question, Project)
Technical type	Definition of the technical type (document, video, wiki etc.) for the specific practical assignment)
Estimated study time (min)	The estimated time needed for an average learner in minutes
Key words	Key words (3 to 10)
Learning outcomes (LOut)	Define the Learning Outcomes for the specific practical assignment (should include learning outcomes from the relevant unit)
Extended practical assignments description	Provide the subject; describe the content of the practical assignment and the expected outcomes.
Preparatory/Additional material	Provide relevant materials needed to deal with the specific practical assignment
Answer extension (word number)	Expected range of words for the accepted answers

7. Assessment Quiz

Assessment Quiz Title	
Assessment Quiz Code	
Assessment Quiz Description	Description of the Assessment Quiz (up to 100 words)
Learning Resource Type	Definition of the learning recourse type for the specific practical assignments (e.g. Example, Case Study, Problem Solving, Text Composition, Question, Project)

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Technical type	Definition of the technical type (document, video, wiki etc.) for the specific practical assignment)
Estimated study time (min)	The estimated time needed for an average learner in minutes
Key words	Key words (3 to 10)
Learning outcomes (LOut)	Define the Learning Outcomes for the specific practical assignment (should include learning outcomes from the relevant unit)
Quiz	Use one of the templates below to prepare your questions and answers, according to your assessment type

8. Assessment Quiz Template 1 “True-False”

Number	e.g. N.1
Question	“...”
TRUE statement	1. ... Mark with bold the TRUE statement.
FALSE statements	1. ... 2. ... 3. ... 4. ...
Response to correct answer (TRUE)	
Response to wrong answers (FALSE)	

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9. Assessment Quiz Templates 2 “Yes-No”

Number	e.g. N.2
Question/ Statement	“...”
Answer (YES)	If the answer YES is correct, Mark with bold the answer YES.
Answer (NO)	If the answer NO is correct, Mark with bold the answer NO.
Response to correct answer	
Response to wrong answer	

10. Assessment Quiz Templates 3 “Selection of Key Answers”

Number	e.g. N.1
Question/ Statement	“Please select the right key activities/answers/statements of the following category:...”
List of WRONG answers	<ol style="list-style-type: none"> 1. ... 2. ... 3. ...
List of RIGHT answers	<p>The right answers are signed in bold always.</p> <ul style="list-style-type: none"> • ... • ... • ...
Response to correct answer	
Response to wrong answer	

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11. Assessment Quiz Template 4 “ Multiple Choice Answers”

Number	e.g. N.1
Question/ Statement/ Image	In response to a question (that may include an image) the respondent chooses from multiple answers.
List of WRONG answers	<ol style="list-style-type: none"> 1. ... 2. ... 3. ... 4. ...
RIGHT answers	The right answer is signed in bold always. <ul style="list-style-type: none"> • ...
Response to correct answer	
Response to wrong answer	

12. Assessment Quiz Template 5 “Numerical Question”

Number	e.g. N.1
Question/ Statement/ Image	A numerical question looks just like a short-answer question in that they enter their answer into a short edit box. The difference is that the answer has to be numerical, and answers are allowed to have an accepted error range.
List of WRONG answers	<ol style="list-style-type: none"> 1. ... 2. ... 3. ... 4. ...
RIGHT answers	The right answer is signed in bold always. <ol style="list-style-type: none"> 5. ...

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Response to correct answer	
Response to wrong answer	

13. Assessment Quiz Template 6 “Matching Questions with Sub-Answers”

Number	e.g. N.1
Question/ Statement	Match the question with one of the sub-answers
Matching question 1	
List of WRONG sub-answers	<ol style="list-style-type: none"> 1. ... 2. ... 3. ... 4. ...
RIGHT sub-answer	The right answer is signed in bold always.
Response to correct answer	
Response to wrong answer	

4. Ind4.0 Professional/VET Courses MOOC Architecture

The 9 core courses and the 3 elective courses were assigned to the partners to provide the contents of the module. The completed outlines of the courses are shown in Table 2.

Table 2: The completed outlines for the courses for VET Programmes as prepared by the consortium partners

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	Course Title/ Lesson	HRS	HEIs
1	Cyber security in Industry 4.0	2	Unsyiah
2	Networking Technologies and Sensors	2	NMU
3	Artificial Intelligence	2	Unsyiah
4	Machine Learning and Big Data Analytics	2	NUBB
5	Cloud Computing Services and Technologies	2	UniKL
6	Robotics and Industry 4.0	2	HOU
7	Digital Transformation and Business Models	2	UTM
8	HCI for Industry 4.0	2	UTM
9	Sustainable Product Design & Manufacturing	2	USU
10	Process management in Manufacturing 4.0	2	UHST
11	Introduction to Agriculture/ Aquaculture 4.0 Ecosystem for Smart Farming	2	UiTM
12	Introduction to Pervasive Health/Health 4.0	2	HOU

The professional/VET course MOOC architecture is shown in Table 3. The detailed components are under Work Package 3.

Table 3: The MOOC architecture for Cyber Security in Industry 4.0

Ind4.0 MOOC building blocks	Title	Description
Section/Module 1	Cyber security in Industry 4.0	To provide students an insight of current security scenario and increasing hacking attempts on various information systems with focus in Industry 4.0 related technology.

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Subsection/Lesson 1	Essentials of Industry 4.0 - Cyber security perspective	Provide an overview of cyber security perspective in Industry 4.0 revolution.
Unit 1	The 4 th Industrial Revolution	Learning Materials: Notes/PowerPoints Reading Materials
Unit 2	Communication	Learning Materials: Notes/PowerPoints Reading Materials
Unit 3	Connectivity	Learning Materials: Notes/PowerPoints Reading Materials
Unit 4	Automation	Learning Materials: Notes/PowerPoints Reading Materials
Unit 5	Data Exchange	Learning Materials: Notes/PowerPoints Reading Materials
Unit 6	Cyber Security Threats	Learning Materials: Notes/PowerPoints Reading Materials
Subsection/Lesson 2	Vulnerabilities of Industry 4.0	Introduce the importance, opportunities, challenges, and examples of cyber security and cyber-attacks in Industry 4.0 era.
Unit 1	Cyber attacks a) Information theft b) System damage c) Product damage d) Motivation for cyber attacks	Learning Materials: Notes/PowerPoints Reading Materials

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Unit 2	Vulnerabilities a) Misconfigured devices b) Outdated equipment c) Outdated applications	Learning Materials: Notes/PowerPoints Reading Materials
Unit 3	Example of attacks a) Mirai botnet b) IP-camera security test c) Smart appliances	Learning Materials: Notes/PowerPoints Reading Materials
Subsection/Lesson 3	Prevention of Attacks	Build-up, develop, and practice the knowledge needed to prevent cyber security attacks in the system
Unit 1	Security Awareness 1) Using IDS	Learning Materials: Notes/PowerPoints Reading Materials
Unit 2	Prevention of Attacks	Learning Materials: Notes/PowerPoints Reading Materials
Unit 3	Strong Password	Learning Materials: Notes/PowerPoints Reading Materials
Unit 4	Strong Encryption	Learning Materials: Notes/PowerPoints Reading Materials
Unit 5	Optimization of Discovery Method	Learning Materials: Notes/PowerPoints Reading Materials
Unit 6	Disabling not Secure Service	Learning Materials: Notes/PowerPoints Reading Materials
Unit 7	Optimization of the Network Structure	Learning Materials: Notes/PowerPoints

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		Reading Materials
Unit 8	Using IDS	Learning Materials: Notes/PowerPoints Reading Materials
Unit 9	Develop a Security Strategy	Learning Materials: Notes/PowerPoints Reading Materials

Table 4: The MOOC architecture for Networking Technologies and Sensors

Ind4.0 MOOC building blocks	Title	Description
Section/Module 2	Networking Technologies and Sensors	Explain the background, types of sensor network technologies, sensor nodes, software and application.
Subsection/Lesson 1	Introduction	Describe about infrastructure of sensing, computing and communication elements.
Unit 1	Definition and background	
Unit 2	History	
Subsection/Lesson 2	Basic wireless sensor network	Introduce basic sensor network and design, types and technology
Unit 1	Sensor node technology	Understand physical structure of sensor nodes

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		including OS, sensor drivers, and hardware
Unit 2	Sensor taxonomy	Define classification of sensor system
Subsection/Lesson 3	Wireless transmission technology	
Unit 1	Wire and wireless sensor network technology	Explore the uses of wire and wireless sensor network technology
Unit 2	Transport control protocol	Determine the architecture of computer and communication network; TCP and UDP protocol
Unit 3	Operating systems	hardware abstraction to application software
Subsection/Lesson 4	Applications	Use of sensor network technology in field of agriculture, traffic control and health care.
Unit 1	Precision agriculture	
Unit 2	Traffic control	
Unit 3	Health care	

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Table 5: The MOOC architecture for Artificial Intelligence

Ind4.0 MOOC building blocks	Title	Description
Section/Module 03	Artificial Intelligence (AI)	The course provides the fundamentals of artificial intelligence – from the concept to the examples of AI-based on the terminology of Industry 4.0. Students will learn AI underlying concepts, and their corresponding application.
Subsection/Lesson 1	AI concept and application areas (especially in Ind4.0)	In this lesson, the students will learn the benefit and challenges of adopting Industry 4.0 on a company, especially from an AI perspective.
Unit 1	Industry 4.0 use cases: <ul style="list-style-type: none"> • Success story and inspiration on AI for Ind4.0 • AI from an academic and practical perspective. • AI development in different countries. • Example of AI application in Ind4.0 	
Unit 2	Machine Learning: <ul style="list-style-type: none"> • Introduction, category and terminology 	

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	<ul style="list-style-type: none"> Techniques of Machine Learning (training, validation and testing) 	
Unit 3	<p>Deep Learning:</p> <ul style="list-style-type: none"> Introduction, category and terminology Techniques of deep learning (training, validation and testing) 	
Unit 4	<p>Example of implementation:</p> <ul style="list-style-type: none"> Voice recognition Object detection Object classification 	
Subsection/Lesson 2	AI in industry 4.0 (surveillance and health care)	In this lesson, the students will learn and discuss one of use case of AI related to Industry 4.0.
Unit 1	<p>Introduction to object detection and classification:</p> <ul style="list-style-type: none"> object detection via machine learning techniques object classification through machine learning techniques object detection via deep learning techniques object classification through deep learning techniques 	

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Unit 2	AI for Ind4.0 in surveillance application: <ul style="list-style-type: none"> • Vehicle classification • Video anomaly detection • Abnormal scene classification 	
Unit 3 (Optional)	AI for Ind4.0 in health care: <ul style="list-style-type: none"> • Computer-Aided Design (CAD) for tuberculosis (TB) disease. • Computer-Aided Design (CAD) for covid-19 disease. 	Webinar and forum discussion.
Subsection/Lesson 3	Get to know deeper AI concepts	In this lesson, the students will learn the deeper concepts that will build up and enhance their knowledge and skill on AI concepts.
Unit 1	Conventional Machine Learning: <ul style="list-style-type: none"> • K-Nearest Neighbor • Linear regression • Probability 	
Unit 2	Deep learning: <ul style="list-style-type: none"> • 2D convolutional neural network (2D CNN) • 3D convolutional neural network (3D CNN) 	

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Unit 3	AI in Ind4.0 through conventional and recent deep learning application: <ul style="list-style-type: none"> • Steel defect classification • Ride-hailing rider classification 	
Subsection/Lesson 4 (Optional)	Hands-on session (training) on applying AI methods	The focus of the training is for the students to learn practical application of AI methods.
Unit 1	Hands-on lab: <ul style="list-style-type: none"> • Training, validation, testing the data (Google Colab) • Implementing two AI demos via Python framework (e.g., Pytorch, Tensorflow, etc.) 	
Unit 2	Training and Certification	Training for certification

Table 6: The MOOC architecture for Machine Learning & Big Data Analytic

Ind4.0 building blocks	Title	Description
Section/Module 4	Machine Learning & Big Data Analytic	The course is designed to equip students with advanced statistical modelling techniques and basic concepts of decision-making process. The course will give the student the

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		basic ideas and intuition behind modern machine learning methods as well as a bit more formal understanding of how, why, and when they work. Thus, students will learn the concepts, techniques, and algorithms in machine learning, beginning with topics such as hierarchical clustering, ordination, linear regression and ending up with more sophisticated techniques such as classification and regression tree (CART, Random Forest).
Subsection/Lesson 1	Introduction to Machine Learning (ML)	In this lesson, the students will learn have the basic idea of how the model looks like and the concept of machine learning (ML) to solve the socio-economic and environmental issues in the era of industry 4.0.
Unit 1	<p>Introduction to machine learning (ML)</p> <ul style="list-style-type: none"> • What is model? • Multivariate table • Decision support system • Machine learning (ML) • ML process & architecture 	This unit will show how the model looks like and provide the conceptual framework of machine learning including process and architecture of model construction.
Unit 2	<ul style="list-style-type: none"> • Unsupervised models • Supervised models 	This unit will focus on the two main types of machine learning (ML) approaches: Unsupervised learning vs. supervised learning algorithm. A

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		tutorial video is provided to illustrate the different types of ML algorithms.
Subsection/Lesson 2	Automatic classification (unsupervised ML methods)	In this lesson, the students will learn the fundamental techniques in clustering or classification, which is one of the most common used ML methods for big data analysis.
Unit 1	<p>Hierarchical clustering methods (hclust)</p> <ul style="list-style-type: none"> • Concept & types of hierarchical clustering (hclust) • Basic algorithm of hclust • Graphic dendrogram • Aggregation criteria & methods • Quality of partition 	This unit contains the detail explanation of concept, algorithm, and graphical methods for hierarchical clustering method (hclust). Students are required to perform the script in R programming to perform hclust with different datasets available in R program. The R script will be provided for computation; interpretation and discussion will be done after the programming session.
Unit 2	<p>Other clustering methods:</p> <ul style="list-style-type: none"> • K-Means model • K-Medoids • SOM (self-organizing map) 	This unit provides options and models to perform classification or clustering based on k-means, k-medoids or self organizing map (SOM), which are among the common used clustering techniques besides hclust. Concept, application with case studies and algorithm will be explained in the unit and R programming will be used to apply above algorithms.
Subsection/Lesson 3	Ordination techniques (unsupervised ML methods)	This lesson focuses on variable reduction techniques using unsupervised machine learning

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		techniques, which are one the well-known methods in ML to solve the problems in the complex data sets.
Unit 1	<p>Principal Component Analysis (PCA)</p> <ul style="list-style-type: none"> • Concept & algorithm • Application of PCA in R programming 	This unit focus on the use of PCA to study the patterns and relationship between variables in the large multivariate table. The unit is combined both theoretical part and practical session to apply PCA algorithm in R program based on the available datasets in basic R packages.
Unit 2	<p>Non-Multidimensional Scaling (NMDS)</p> <ul style="list-style-type: none"> • Concept & algorithm • Application of NMDS in R programming • Concept and algorithm of factorial correspondence analysis (FA) 	This unit focus on the use of NMDS model on the large multivariate table. NMDS is one of the common use technique similar to PCA based on the (dis)similarity distance matrix with wider application on different datasets (categorical or numerical database). The unit is combined both theoretical part and practical session to apply NMDS algorithm in R program based on the available datasets in basic R packages.
Unit 3	<p>Constrained ordination techniques</p> <ul style="list-style-type: none"> • Concept & algorithm of CCA and RDA • Application of CCA/RDA in R programming 	This unit focus on the use of constrained ordination techniques (tri-plot) basically canonical correspondence analysis (CCA) and redundancy discriminant analysis (RDA) to solve the problems in the complex datasets. Both CCA and RDA are the tri-plot techniques used to

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		<p>investigate co-inertia or relationship between two multivariable tables.</p> <p>The unit is combined both theoretical parts and practical session to apply RDA/CCA algorithm in R program based on the available datasets in basic R packages (ade4, vegan).</p>
Subsection/Lesson 4	Prediction (supervised ML methods)	<p>This lesson focuses on the other type of machine learning algorithm calling supervised learning algorithm or prediction. Thus, the basic and sophisticated prediction models will be introduced in the lesson along with the application of available datasets in R programs. Students will learn to use regression models (LM, GLM, GAM) and others powerful predictive models such as LDA, CART, Random Forest (RF) to solve the problems within the complex multivariate tables.</p>
Unit 1	<p>Supervised learning models</p> <ul style="list-style-type: none"> • Concept and procedure • Model quality & uncertainty 	<p>This unit focus on the explanation of concept and procedure of different supervised machine learning techniques including basic ML models such as GLM & LDA and the sophisticated models such as CART and RF. Accordingly, quality, model performance, calibration & validation process will be introduced in this unit.</p>

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Unit 2	<p>Application of supervised ML</p> <ul style="list-style-type: none"> • General linear model (GLM) • Linear discriminant analysis (LDA) • Classification & regression tree (CART) 	<p>This unit focus on the application of different supervised ML to model the large dataset using GLM techniques and other predictive models such as LDA, CART and RF. Performance model testing will be performed and discussed in this unit as well. Students are required to perform the analysis in R program using available datasets in R packages.</p>
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Table 7: The MOOC architecture for Cloud Computing Services and Technologies

Ind4.0 MOOC building blocks	Title	Description
Section/Module 5	Cloud Computing Service and Technologies	
Subsection/Lesson 1	Introduction to Cloud Computing	What is cloud computing supported services, and how distributed computing enhances performance and reliability.

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Subsection/Lesson 2	Type of Cloud Services	<p>Identify the available cloud service platforms</p> <p>Identify and explain the three major services of Cloud computing: SaaS, PaaS, and IaaS.</p>
Subsection/Lesson 3	Type of Cloud Deployment	<p>Understand the differences between cloud deployment models.</p> <p>Define High Performance Cloud Computing and its benefits.</p> <p>Explain the big data cloud and how it is a solution for data analytics.</p>
Subsection/Lesson 4	Hosting Technologies	Identify cloud computing hosting technologies
Subsection/Lesson 5	Cloud Computing Service Providers	Identify the available cloud service providers

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Table 8: The MOOC architecture for Robotics and Industry 4.0

Ind4.0 MOOC building blocks	Title	Description
Section/Module 06	Robotics and Industry 4.0	The main goal of Robotics and Industry 4.0 module is to help learner get in touch with the ways robotics can improve productivity, produce a high-quality product at a low price and meet customer expectations in Industry 4.0 environments. We will discuss the role of robotics and automation in Industry 4.0, the advantages and disadvantages of robotics in Industry 4.0, various challenges and its applications.
Subsection/Lesson 1	Introduction to Robotics	In this lesson, the students will learn the fundamental concepts of robotics. Also, they will be introduced to the latest technological developments in the field and specific applications regarding manufacturing, maintenance and assembly.
Unit 1	Introduction to Robotics <ul style="list-style-type: none"> • Classification, applications and impact 	Learning Materials: Notes/Slides

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	<ul style="list-style-type: none"> ● Classification of industrial robotics and manufacturing solutions 	<p>External Link</p> <p>Discussion Forum</p>
Unit 2	<p>Recent Technological Components of Robots</p> <ul style="list-style-type: none"> ● Artificial Intelligence ● Internet of Robotic Things ● Cloud Robotics ● Cognitive Architecture for Cyber-Physical Robotics 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>External Link</p>
Unit 3	<p>Industrial Robotic Applications</p> <ul style="list-style-type: none"> ● Manufacturing ● Maintenance ● Assembly 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p> <p>External Link</p>
Subsection/Lesson 2	Robots in Industry 4.0	<p>In this lesson, the students will learn and discuss the fundamental concept of human-computer interaction, in particular ways of collaboration but also safety issues. The way of integrating robots in smart factories and the efficient utilization of methods implementing artificial intelligence will be analyzed in this lesson.</p>

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Unit 1	<p>Human-Robot Interaction Efficiency</p> <ul style="list-style-type: none"> ● Human-Robot Collaboration ● Safety Issues in Human-Robot Interaction ● The HRI Efficiency 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p> <p>External Link</p> <p>Discussion Forum</p>
Unit 2	<p>AI Reasoning Methods for Robotics</p> <ul style="list-style-type: none"> ● Knowledge Representation and Processing ● Reasoning and Decision Making ● Plan-Based Robot Control 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>External Link</p>
Unit 3	<p>Robots in Smart Factories</p> <ul style="list-style-type: none"> ● Introducing the Smart Factory ● Real-World Smart Factories ● Industry 4.0: The Way Forward 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>External Link</p>
Subsection/Lesson 3	How Robots work	<p>In this lesson, learners will be introduced to the basic operating principles of robots. Specifically in the way they can be programmed and the essential elements of their</p>

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		architecture. In addition, an extensive analysis will be made on the different types of sensors available and how the estimation is performed.
Unit 1	<p>Robotic Systems Architectures and Programming</p> <ul style="list-style-type: none"> • Architectural Components • The Art of Robot Architectures • Implementing Robotic Systems Architectures 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Discussion Forum</p>
Unit 2	<p>Robot Learning</p> <ul style="list-style-type: none"> • What Is Robot Learning • Model Learning • Reinforcement Learning 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>External Link</p>
Unit 3	<p>Sensing and Estimation</p> <ul style="list-style-type: none"> • Range Sensing • Proximity Sensing • Touch Sensors • Force and Torque Sensing • Inertial Sensing, GPS and Odometry 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>External Link</p>
Unit 4	Training and Certification	Training for certification

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Table 9: The MOOC architecture for Digital Transformation and Business Model

Ind4.0 MOOC building blocks	Title	Description
Section/ Module_07	<p>Digital Transformation and Business Models</p> <p>Lesson 1: Fundamentals of Digital Transformation</p> <p>Lesson 2: Business Models</p> <p>Lesson 3: Digital Transformation Strategy</p>	<p>This course would expose learners on how digitalization has fundamentally changed the way enterprises operates which also affecting their business models and supply chain dynamics. The course would allow learners to manage and ties together strategy, innovation and organizing digitalization agenda in more concrete ways by considering the following:</p> <ul style="list-style-type: none"> • Enterprises’ digital logic, which impacts all levels of organizational life including strategies, business models and competencies. • Core operational challenges for organizations building on a digital logic and business model transformation • Digitalization governance and dynamic capabilities, • Digital and business platforms, digital transformation, risk, and value creation.

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		<ul style="list-style-type: none"> Digitalization strategic implementation and monitoring
Subsection/ Lesson 1	Fundamentals of Digital Transformation	In this lesson, the students will learn the fundamental concept of digital transformation.
Unit 1	Digital Disruption <ul style="list-style-type: none"> The Impact of Digitalization Digital Business Digital Platforms 	Learning Materials: Notes/Slides Video External Link
Unit 2	Digital Transformation <ul style="list-style-type: none"> The Essentials of Digital Transformation Strategic Challenges of Digital – Innovation and Transformation 	Learning Materials: Notes/Slides Video External Link
Unit 3	Case Study – Digital Transformation <ul style="list-style-type: none"> Hua Wei. Using Blockchain to Coordinate Federal Processes: The Case of Germany’s Federal Office for Migration. 	Learning Materials: Notes/Slides Video
Subsection/ Lesson 2	Business Models	In this lesson, the students will learn and discuss the basic business models.
Unit 1	Business Models <ul style="list-style-type: none"> Business Models by Industry 	Learning Materials: Notes/Slides

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	<ul style="list-style-type: none"> ○ Manufacturing ○ Healthcare ○ Finance ○ Commerce 	Video
Unit 2	<p>Business Model Innovation</p> <ul style="list-style-type: none"> ● What It Is and Why It's Important ● Examples of Business Model Innovation 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p>
Unit 3	<p>Case Study on Business Model Innovation</p> <ul style="list-style-type: none"> ● Airbnb ● Alibaba ● IKEA ● Tesla 	Discussion Forum/Quiz
Subsection/ Lesson 3	Digital Transformation Strategy	In this lesson, the students will learn the digital transformation strategy. The students also will be exposed to propose appropriate digital transformation strategy for enterprises.
Unit 1	<p>What is Digital Transformation Strategy?</p> <ul style="list-style-type: none"> ● Where to Start the Digital Transformation Strategy? ● Skills required to transform a business ● Digital Transformation Strategy Frameworks. 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p>

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Unit 2	<p>The Process of Digital Transformation</p> <ul style="list-style-type: none"> • Digital Reality: Current Status Evaluation • Digital Ambition: Setting Objectives • Digital Potential: Establishing Options • Digital Fit: Suitability Evaluation • Digital Implementation: Enabling and Realization. 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p>
Unit 3	<p>Digital Transformation Strategy for Enterprise</p> <ul style="list-style-type: none"> • Project 	<p>Learning Materials:</p> <p>Discussion Forum</p> <p>Presentation Tools</p>

Table 10: The MOOC architecture for HCI in Industry 4.0

Ind4.0 MOOC building blocks	Title	Description
Section/Module 08	HCI in Industry 4.0	<p>The course provides the fundamentals of human computer interaction (HCI) and how it supports Industry 4.0</p> <p>The course entails user study, user-centered design, and other models and theories in HCI. This course integrates computer science, behavioral</p>

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		science, design and several other studies.
Subsection/Lesson 1	Essentials of Human Computer Interaction	In this lesson, the students will learn the fundamental concept of Human Computer Interaction (HCI) in Industry 4.0
Unit 1	The fundamental of HCI: <ul style="list-style-type: none"> ● Introduction ● Usability ● User-centered design 	Learning Materials: Notes/Slides Video External Link
Unit 2	The Computer <ul style="list-style-type: none"> ● Text Entry Devices ● Devices for virtual reality and 3D devices ● Display Devices 	Learning Materials: Notes/Slides Video External Link
Unit 3	Emotions and Memory <ul style="list-style-type: none"> ● Introduction ● Emotions ● Individual Differences 	Learning Materials: Notes/Slides Video
Subsection/Lesson 2	The Interaction	In this lesson, the students will learn and discuss the fundamental concept of Interaction between human and computer
Unit 1	Interaction <ul style="list-style-type: none"> ● Model of Interaction ● Framework and HCI 	Learning Materials: Notes/Slides

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		Video
Unit 2	<p>Context</p> <ul style="list-style-type: none"> • The context of interaction • Experience, Engagement, and Fun 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p>
Unit 3	<p>Learning from the industry</p> <ul style="list-style-type: none"> • Case Study on HCI in Industry 4.0 	Discussion Forum/Quiz
Subsection/Lesson 3	Interaction Design	In this lesson, the students will learn the basics of interaction design, its process and elements. The students also will be exposed to designing a prototype using fundamental concept of user-centered design
Unit 1	<p>Introduction</p> <ul style="list-style-type: none"> • What is Design • Design Interaction • Design Process 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p>
Unit 2	<p>Design Elements</p> <ul style="list-style-type: none"> • User Focus • Scenarios • Navigation Design • Iterative 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p>

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Unit 3	Learning by Doing <ul style="list-style-type: none"> ● Prototyping in Practise 	Learning Materials: Discussion Forum
Unit 4	Training and Certification	Training for certification

Table 11: The MOOC architecture for Sustainable Product Design & Manufacturing

Course Title: Sustainable Product Design and Manufacturing
Course Code: INDVET9
Course Summary
<p>Sustainable product design and manufacturing is the approach to creating products and services that have considered the environmental, social, and economic impacts from the initial phase through to the end of life. Sustainable product design and manufacturing present different ways and means by which a product can address all three pillars of sustainability—environmental conservation, social sustainability, and economic sustainability. Sustainable product design and manufacturing include both the manufacturing of "sustainable" products and the sustainable manufacturing of all products. It also includes the development of sustainable manufacturing systems and enterprises and the study of the societal impact of manufacturing. Therefore, this course is designed to equip graduate students with the vision of understanding the design and manufacture of products based on the three pillars of sustainability: environmental, social and economic. This course gives an overview of concepts and techniques for sustainable product design and manufacturing to create (design & manufacture) and distribute (supply chain) of products and services through economically sound processes. The course will give the student the fundamental ideas on minimizing negative environmental impacts, the use of energy and natural resources, while adopting socially responsible practices for employees, local communities and society, across the entire life cycle of products and services. The underlying theme in the course is understanding the creation of manufactured products through economically-sound processes that minimize negative environmental impacts while conserving</p>

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energy and natural resources. More importantly, the course will provide students the concepts of improving the efficiency of producers' equipment and processes, lowering energy consumption, decreasing manufacturing time, reducing waste, and use less material — all of which can provide significant cost savings for producer and customers. The session includes theoretical introductions and practical concepts already developed in industries.

Table 12: The MOOC architecture for Process management in Manufacturing 4.0

Ind4.0 building blocks	Title	Description
Section/Module 10	Process Management in Manufacturing 4.0	The course provides the fundamentals of process management in manufacturing 4.0 which represents implementing ind4.0 on manufacturing process. Students will learn underlying concepts and theories of process management in manufacturing, and their corresponding implementations.
Subsection/Lesson 1	Concepts in Ind4.0)	In this lesson, the students will learn the benefit and challenges of adopting Industry 4.0 on manufacturing.
Unit 1	Introduction to Industry 4.0: <ul style="list-style-type: none"> • Industrial evolution • IoT/loE • Cyber-security • Cloud computing 	This unit will show actual course content of introduction to Ind4.0: <u>Videos, problems/quizzes, reading material, discussion forums.</u>

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	<ul style="list-style-type: none"> • 3D-printing • Robotics 	
Unit 2	<p>Cyber-physical system:</p> <ul style="list-style-type: none"> • Machine system • Machine functions • Installation and software 	A unit focuses on actual course content of cyber-physical system: <u>Videos, problems/quizzes, reading material, discussion forums.</u>
Unit 3	<p>Digital transformation:</p> <ul style="list-style-type: none"> • Ind4.0 manufacturing • 	A unit contains actual course content on ind4.0 transformation and digitalization: <u>Videos, problems/quizzes, reading material, discussion forums.</u>
Subsection/Lesson 2	Process Management	In this lesson, the students will learn and discuss about process management in manufacturing 4.0
Unit 1	<p>Process design and Modelling:</p> <ul style="list-style-type: none"> • planning the process • modelling 	A unit contains actual course content on process planning and modelling: <u>Videos, problems/quizzes, reading material, discussion forums.</u>
Unit 2	<p>Process Execution:</p> <ul style="list-style-type: none"> • data acquisition and data processing • machine-to-machine communication • human-machine interaction 	A unit contains actual course content on process execution: <u>Videos, problems/quizzes, reading material, discussion forums.</u>
Unit 3	<p>Process Monitoring:</p> <ul style="list-style-type: none"> • process performance indicators • basic performance parameters 	A unit contains actual course content on process monitoring: <u>Videos, problems/quizzes, reading material, discussion forums.</u>

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	<ul style="list-style-type: none"> • big data (IoT/IoE) • dynamic organizational analysis • process optimization • right-time monitoring • process simulation 	
Unit 4	<p>Process Improvement</p> <ul style="list-style-type: none"> • monitoring and data collection • continual improvement 	A unit contains actual course content on process improvement: <u>Videos, problems/quizzes, reading material, discussion forums.</u>
Subsection/Lesson 3	Practical and training on Process Management in Manufacturing 4.0	This lesson focuses on training for the students to learn practical implementation of process management.
Unit 1	<p>Hands-on lab/practical:</p> <ul style="list-style-type: none"> • Training • Implementing Ind4.0 on process management 	This unit contains more components, which focus on implementing process management in manufacturing 4.0: <u>Videos, problems/quizzes, reading material, discussion forums.</u>
Unit 2	<p>Risk management:</p> <ul style="list-style-type: none"> • maintenance • manufacturing methods and tools • manufacturing process management • human resource • machine environment • machine and manufacturing technology 	This unit contains more components, which represent the actual course content on risk management in process management : <u>Videos, problems/quizzes, reading material, discussion forums.</u>

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Table 13: The MOOC architecture for Introduction to Agriculture/Aquaculture 4.0

Ind4.0 building blocks	Title	Description
Section/Module 8	Ecosystems for Smart Farming	Provides an overview of precision farming concepts and the tools of precision farming (GPS, GIS and VRT). Introduces the use of each of these tools within the processes of a precision farming system. Provides hands-on activities in the use of these tools. Discusses economic and environmental benefits.
Subsection/Lesson 1	What is Smart Farming/Aquafarming?	Provide an overview of precision farming concepts.
Unit 1	Orientation and Introduction a. Precision Farming/Aquafarming b. Adoption of IR4.0 in the implementation of Precision Farming/Aquafarming	Video Lectures Assessment – 10 multichoice questions reading material, discussion forums.
Unit 2	Benefits of Smart Farming a. Economic Benefits b. Environmental Benefits	Video Lectures Assessment – 10 multichoice questions

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	c. Farm Management Improvement	
Unit 3	Incorporate Cross-Industry Technologies and Applications <ul style="list-style-type: none"> a. Internet of Things (IoT) b. Automated of skills and workforce c. Data-driven farming/aquafarming 	Video Lectures Assessment – 10 multichoice questions
Subsection/Lesson 2	Tools of Precision Agriculture	Introduce the use of tools within the processes of a precision farming system
Unit 1	Remote Sensing <ul style="list-style-type: none"> a. Applications in agriculture b. Remote sensing basics. c. Correlating imagery to other crop production data d. Remote sensing data sources 	Video Lectures Assessment – 10 multichoice questions
Unit 2	Global Positioning System (GPS) <ul style="list-style-type: none"> a. GPS systems available for use in agriculture b. How GPS locates positions c. Factors that affect GPS accuracy and techniques to improve accuracy 	Video Lectures Assessment – 10 multichoice questions

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	d. Agricultural GPS applications: vehicle guidance and auto-steering, variable rate technology, remote sensing, yield monitoring, and analysing soil properties.	
Unit 3	<p>Geographic Information System (GIS)</p> <p>a. GPS Basics (Space Segment, Receiver Segment, Control Segment)</p> <p>b. Error and correction</p> <p>c. Function and usage of GPS</p>	<p>Video Lectures</p> <p>Assessment – 10 multichoice questions</p>
Subsection/Lesson 3	Auto-Guidance Systems	Identify the role and importance of Agriculture/Aquaculture 4.0
Unit 1	Components and technology of auto-guidance systems	Video Lectures
Unit 2	Drone Technology	Assessment – 10 multichoice questions
Unit 3	<p>Yield Monitoring Systems</p> <p>a. Components, operation, calibration and common malfunctions</p> <p>b. Interpreting yield data</p> <p>c. Correlating yield data with other data.</p>	<p>Video Lectures</p> <p>Assessment – 10 multichoice questions</p>

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Table 14: The MOOC architecture for Introduction to Pervasive Health/ Health 4.0

Ind4.0 MOOC building blocks	Title	Description
Section/Module 06	Introduction to Pervasive Health/ Health 4.0	
Subsection/Lesson 1	Introduction to Health 4.0	<p>Health 4.0, as part of the Industry 4.0 paradigm, concerns the transformation of health-related processes through the integration of modern technologies such as sensors, communication, and computational processing. Technologies such as Cyber Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Machine Learning, and Data Analytics are considered to be the different drivers necessary for the transformation.</p> <p>The aim of this course is to provide an introduction to Health 4.0, its major systems and technologies and how new products and services will impact business and society. Expose the importance of privacy and security of data in</p>

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		healthcare information systems.
Unit 1	<p>Introduction to Health 4.0</p> <ul style="list-style-type: none"> • Overview of the Health 4.0 Paradigm • Evolution from Health 1.0 to Health 4.0 • Core Components of Health 4.0 	<p>Learning Materials:</p> <ul style="list-style-type: none"> • Notes/Slides • External Link • Discussion Forum
Unit 2	<p>Technologies Driving Health 4.0</p> <ul style="list-style-type: none"> • Cyber-Physical Systems and Their Role in Healthcare • Internet of Things (IoT) in Health Monitoring • The Impact of Cloud Computing on Health Data Management 	<p>Learning Materials:</p> <ul style="list-style-type: none"> • Notes/Slides • External Link
Subsection/Lesson 2	Implementation and Implications of Health 4.0	In this lesson, the students will learn and discuss the fundamental concepts, methods and tools for the implementation of Health 4.0
Unit 1	<p>Data-Driven Healthcare</p> <ul style="list-style-type: none"> • Machine Learning and Predictive Analytics in Health • Big Data Analytics: Turning Data into Insights 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>Video</p> <p>External Link</p>

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	<ul style="list-style-type: none"> • Case Studies of Data Analytics in Healthcare 	Discussion Forum
Unit 2	<p>Privacy, Security, and Future Trends</p> <ul style="list-style-type: none"> • Protecting Patient Data: Privacy and Security Best Practices • Legal Framework and Ethical Considerations • Emerging Trends and Future Directions in Health 4.0 	<p>Learning Materials:</p> <p>Notes/Slides</p> <p>External Link</p>

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