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1 Introduction

The objective of deliverable D3.1 is to provide the detailed problem-based learning path for the training actions. Within this task the academic partners will develop the training path for students and professionals with details of its characteristics and instruments to foster a learner-centered education. This document reviews core aspects of the problem-based learning method. Then it explains the global training topics under the scope of factories of the future and within the training ecosystem. A guideline for the educational material development (specifications, evaluation method, and templates) is then proposed. Finally, a detailed list of training offers provided by the DigiFoF Competence Network is presented.

2 The problem-based learning method

The problem-based learning (PBL) method aims at orientation and transformation of experience based on active methods, through which participants learn by means of playing a role in a scenario, studying a case, or solving a problem by collaborative solutions (Wyness and Dalton, 2018).

Different taxonomies of problem-based learning methods exist (Johnstone and Stanley, 1998). The implementation alternatives vary from lecture-based, with limited use of cases, to the student-centered problem-based method with evaluation (**Error! Reference source not found.**). Choosing an implementation method depends on the subject and goals of the training course.

Table 1 Summary of PBL implementation alternatives (Johnstone and Stanley, 1998)

Taxonomy of methods	Cases characteristics	Instructor role	Students role
Lecture-based cases	Short cases to illustrate points made during the lecture	-Giving lecture with short cases	Little active role
Case-based lectures	Longer well-structured cases contains all necessary factual information, prior to lecture to illustrate points made during the lecture	-Giving lecture with longer cases	Little active role
Case method	Complex case contains all necessary factual information, prior to lecture	-Giving little or no lecture -Facilitating discussion	Interactively discussing the case in small groups
Modified case-based method	Complex case containing initial representation of the problem is provided <i>prior to lecture</i>	-Giving little or no lecture -Ensuring that the students' understanding of the case is correct	Acquiring additional relevant information from outside the research
Problem-based method	Complex case in the form of a simulated interaction among participants	-Active role -Reviewing technical knowledge that applies to the present case	Participating in cases

Taxonomy of methods	Cases characteristics	Instructor role	Students role
Reiterative problem-based method	Complex case in the form of a simulated interaction among participants	-Active role -Reviewing technical knowledge that applies to the present case.	- Re-evaluating the case after completion -Evaluating the information resources they used in solving the case to see if other information or other information search strategies would have been more appropriate. -Evaluating their knowledge of the case as well as the problem solving skills they used to complete it.

This classification is important to properly define the training content, objectives, methodology, and evaluation process (Johnstone and Stanley, 1998; Wyness and Dalton, 2018). In doing so, next sections are dedicated to defining the training content, specification, and evaluation.

3 The training ecosystem for FoF design

The training ecosystem designed by the DigiFoF project aims at developing an innovative training method for acquiring digital skills for the factories of the future. It uses knowledge mapping with a multidisciplinary approach on topics related to FoF. In this matter, topics are proposed in different levels of education as well as their required Infrastructure and tools.

3.1 Topics and level of education

DigiFoF project adopts an innovative training approach based on problem-based learning by supporting, guiding, and monitoring participants during the training process. It provides an applicative education to enhance the participants' competences on broad range of FoF design related domains. It brings together both industries and academics collaborating to set up a training network.

The training network established by DigiFoF uses modular units of training topics, innovative training methods, and tools to equip academic and industrial professionals with subject-oriented skills as well as cognitive skills such as collaborative working, creativity, critical thinking, communication skills, and problem solving.

The modular units of training will cover the whole FoF design domain including strategy-, processes-, and systems-oriented topics (**Error! Reference source not found.**).

➤ Strategy-oriented topics (Level 1)

Strategy-oriented topics focus on defining and implementing successful strategies for FoF design but also on effects of Industry 4.0 revolution and include subjects such as:

- New business models
- Product-Service-Systems (PSS)

- Customer-orientation (using methods like design thinking and open innovation to foster innovation and creativity)
- Smart city: Smart city modelling becomes a necessity and represents an indirect effect of Industry 4.0 revolution. The industrial evolution has both benefits (increasing wellbeing) and drawbacks (city crowding). The level of welfare of many families can be measured by the number of owned cars; in many cases, the number more than one. But this means much more traffic which includes the public and heavy goods transport, creating congestion and, finally, air and noise pollution. Also, parking space and other infrastructure problems are the consequence of city crowding. For educational and demonstration purposes the OMiLAB Package contains three demonstration scenarios, in line with the architecture of the Evaluation Space. The third Demonstration Scenario links all three architectural layers - the Business Layer, the Conceptual Modelling Layer and the Proof of Concept Layer - together in a Smart City/Smart Parking teaching example. It employs the mBot on the CPS-Proof of Concept Layer and the SAP Scenes figures on the Business Layer as well as all modelling tools.

➤ **Process-oriented topics (Level 2)**

Process-oriented topics include management and transformation of business process and enterprise architecture aspects supported by Factory of the Future mainly in subjects as:

- Business Process Management (BPM)
- Business Process Re-Engineering (BPR)
- Management of the ICT enterprise architecture
- Product-lifecycle management using methods like domain specific languages
- Formalization mechanisms
- Modeling and simulation-based design of systems and processes.

➤ **Systems-oriented topics (Level 3)**

Systems-oriented topics consider technological features (hardware and software) of the digital transition for FoF such as:

- Cyber-Physical Systems (CPS)
- Digital factory reference architecture (standard IEC TR 62794),
- Semantics (OWL and RDF)
- Automation of products and production lines (standards IEC62714, IEC61987, ISO13584),
- Product-service-data-transmission (ISO13584)
- Information system security management (ISO/IEC 27000)
- Network security (IEC62443) and cyber-security
- Computer Vision Applications

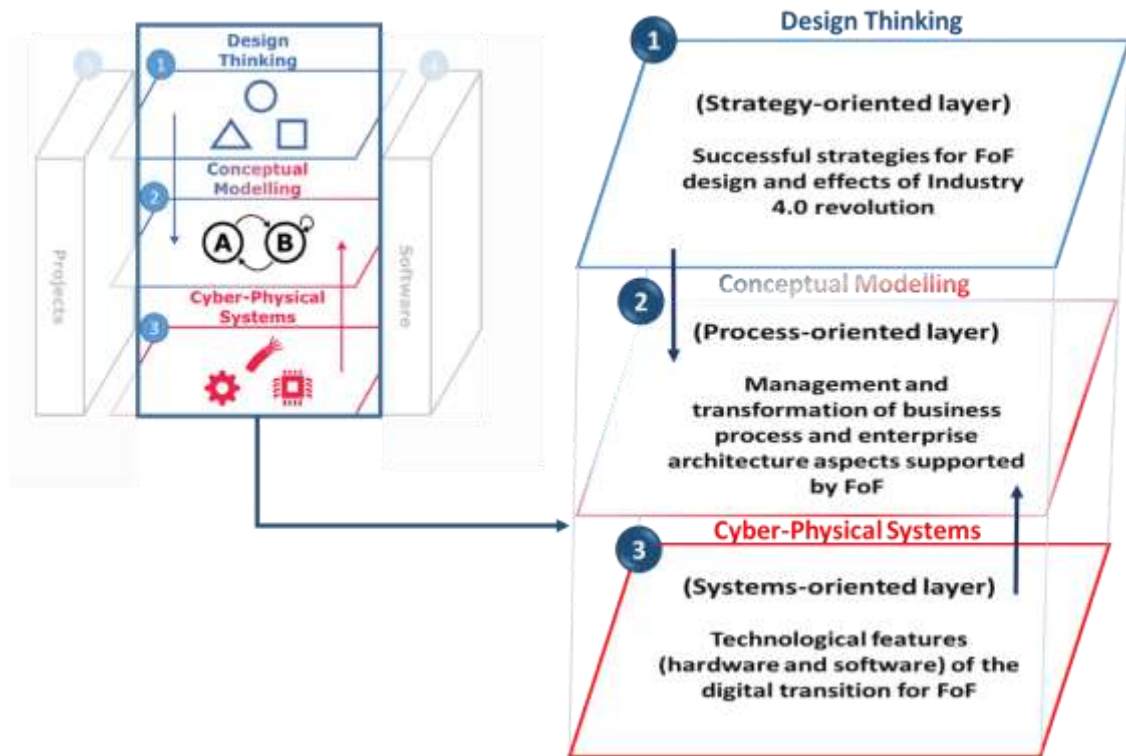


Figure 1 OMiLAB DigiFoF training topics

3.2 Infrastructure and tools

DigiFoF project also provides the infrastructure and tools for each training level and software for all layers (as a baseline, currently more than 40 tools are available at ww.omilab.org) as well as individual learner projects or industrial cases using all layers' tools (**Error! Reference source not found.**). OMiLAB4FoF Design Laboratories are physical or virtual laboratories (educational and experimental environments) to support problem-based learning for industrial and academic stakeholders to learn and apply FoF design knowledge.

Besides the main OMiLAB laboratory as a starting basis, five more national laboratories will be created during the project (**Error! Reference source not found.**), establishing national nodes of the competence network. Each of these educational node acts as a key national actor to develop the culture of FoF Design Methods and Tools. These national laboratories have also their proper specificities and key orientations, leading to develop complementary aspects of the educational material. This is underlined by the educational applications of OMiLAB, emphasized in Table 2.

Table 2 Overview of OMiLAB4FoF Laboratories

OMiLAB4FoF Laboratories	educational applications
OMILAB France (EMSE)	<ul style="list-style-type: none"> ▪ Vocational training on Service Delivery Process Management ▪ Vocational training on PSS design and Business Models ▪ Training of master students on Business Process Reengineering ▪ Training of research master students on Meta-modelling through ADOxx platform

OMiLAB4FoF Laboratories	educational applications
	<ul style="list-style-type: none"> ▪ Training of master students on PSS design method and tool
OMILAB Italy (UNIBG)	<ul style="list-style-type: none"> ▪ Vocational training on the identification of innovative Product Service Systems (Adopting Scene2Model). ▪ Vocational training on the lifecycle management of products and services. ▪ Vocational trainings on Service Operations Management ▪ Vocational trainings on Business process analysis and re-engineering. ▪ Training of Master Students on Design thinking to develop new solutions. ▪ Training of Master Students on process modelling languages, tools and simulation.
OMILAB Romania (ULBS)	<ul style="list-style-type: none"> ▪ Training of Research Master Students on Smart city challenges – modeling with ADOxx ▪ Vocational training about Scene2model and Emotion Recognition for employees ▪ Vocational training about Machine Vision for Manufacturing Industry Application ▪ Image recognition applications: parking lot detection ▪ Training of Research Master Students on the use of modeling and simulation-based design and optimization of manufacturing systems and processes on the ADOxx platform ▪ Training of Research Master Students on the Petri Nets based automation of manufacturing systems
OMILAB Poland (UNIBIAL)	<p>Training of Master Students on Business Process Management, including:</p> <ul style="list-style-type: none"> ▪ Business process identification and analysis; ▪ Business process modelling and analysis with Adonis and ADOxx; ▪ Business process simulation with Adonis.
OMILAB Finland (UNIOULU)	<ul style="list-style-type: none"> ▪ Vocational training about Bee-up model based on ADOxx platform ▪ Robotics application: e.g. non-oats detection ▪ Arm Robot and mobile Robot cooperation application ▪ Aerial Robot and mobile Robot cooperation application: fast delivery process ▪ Training of Research Master Students on the use of UML, EPC, flow chart and Petri Nets to construct and simulate the process of using robots in Virtual Laboratory

4 Educational material development

4.1 The training specifications

All information collected during the analysis of training needs is translated into training specifications. The training specification is a document that contains the details of training and expected results. It makes it possible to clarify the expectations and conditions for organizing the training action. For each training topic, its participants and specifications will be detailed. The training specifications are defined by means of 16 questions presented in Table 3.

Table 3 The training specification details

Training specification	Explanation
Organizer	Name of the training institute, country
Training Topic	The training topics should deliver one or more competences related to FoF design. DigiFoF proposes three main categories of topics (proposed in section 2) to cover FoF design (strategy-, processes-, or systems-oriented topics). These topics and sub-topics proposed can be detailed according to the need of the training.
Training objectives	Describe what skills, competences, or knowledge participants will learn at the end of the training.
Method	Defines phases or steps of the training.
Target groups	Define the participants (e.g. professionals from the same company).
Recommended composition	A group could be homogeneous or heterogeneous (Mix of jobs, abilities, gender, work experience).
Recommended size of groups	Different categories as less than 10 persons, between 10 and 20, or more than 20.
Training duration	Based on the training needs and the project target (estimated 3x5 days in WP4).
Mode of tutoring	Based on Table 1 and defines the various instruments such as lecture, case, tutor role, and participants' role.
Mode of provision	Can be physical, virtual, or blended learning.
Tools and resources to be used (technological-support tools)	Either outside or from OMiLAB laboratories.
Recommended preparation	Defines the necessary information (e.g. having some information about the company, its strategy, and activities).
Modes of working in teams	Concerns the team animation and collaboration method (e.g. playing role, collaborative problem-solving, individual Q&A).
Communication and cooperation mode	E.g. Facebook, social bookmarking, photo or video sharing, wiki documents, word documents, instant messaging or texting, the group workspace, etc.
Necessary abilities to tackle the tasks of open problems	Core skills like research skills, critical analysis, problem solving, report writing, presentation skills, communication skills, organization skills, time management, and group working skills, presentation skills (i.e. soft and transferrable skills).
Knowledge prerequisites	Domain specific knowledge for entry level.

4.2 The training evaluation

Evaluation is considered as the final phase of the problem-based learning method. Two types of evaluations can be considered as:

1- The assessment of learning outcomes using different methods such as:

- Quiz
- Evaluation based on open-ended questions
- Case analysis
- Group work reports.

2- The training evaluation:

- Hot evaluation (at the end of the training)

- Post-training evaluation (on the job).

The training evaluation questionnaires are presented in annex B, C, and D of D6.1. These templates are represented in the annex of this document. These questionnaires will be filled by the attendees, either at the end of each training (Hot evaluation) or as the post-training evaluation (on the job). According to D6.1, the training evaluation consists of list of event’s attendees, participant’s feedback form, and event report template (Appendix I

Annexes from D6.1 for **training evaluation** at the end of this document).

5 List of training units provided by the DigiFoF Competence Network

During the project, the DigiFoF Competence Network provides various pedagogical courses based on problem-based learning (Figure 2).

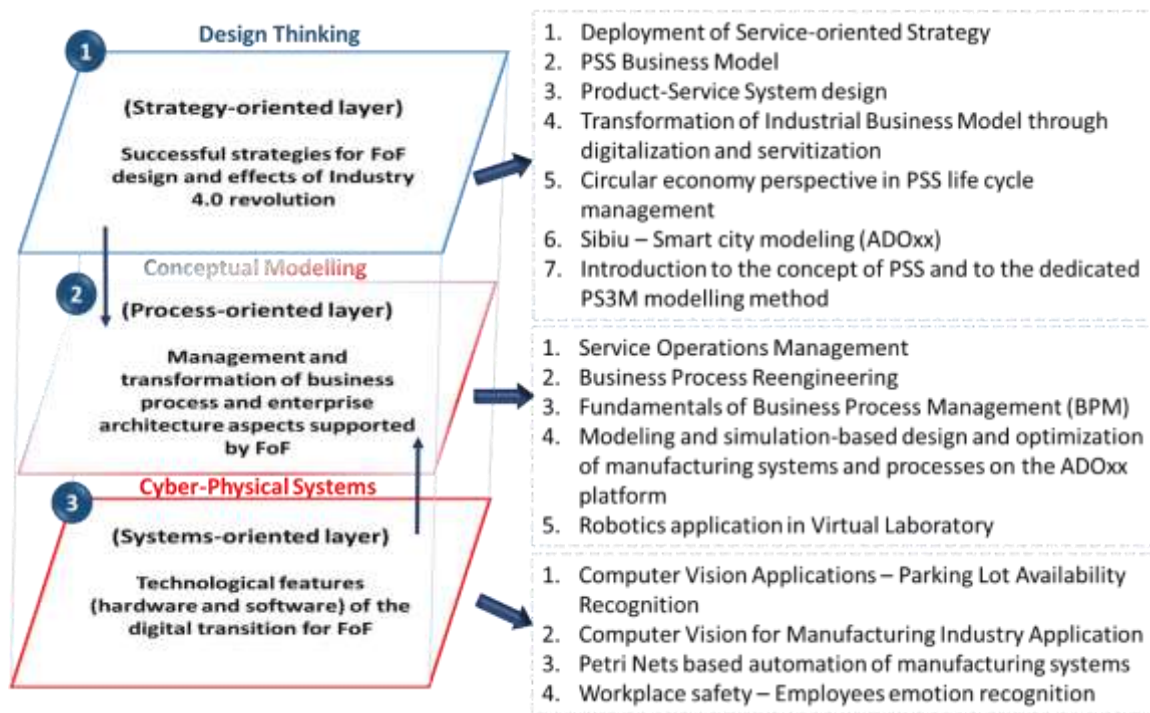


Figure 2 Training courses provided by the project

These training courses are listed in **Error! Reference source not found.** and the details of each course are presented in the following sections.

Table 4 List of training courses provided by the Project partners

Item	Training topic	Organizer
1	Strategy-oriented topics: Business Model	EMSE-France
2	Strategy-oriented topics: Product-Service System design	EMSE-France

Item	Training topic	Organizer
3	Strategy-oriented topics: Transformation of Industrial Business Model through digitalization and servitization	EMSE-France
4	Strategy-oriented topics: Introduction to the concept of PSS and to the dedicated PS3M modelling method	EMSE-France
5	Strategy-oriented topics: Integrating circular economy perspective in PSS life cycle management	EMSE-France
6	Strategy-oriented topics: Deployment of Service-oriented Strategy	EMSE-France
7	Strategy-oriented topics: Sibiu – Smart city modeling (ADOxx)	ULBS - Romania
8	Systems-oriented topics: Workplace safety – Employees emotion recognition	ULBS - Romania
9	Systems-oriented topics: Computer Vision for Manufacturing Industry Application	ULBS-Romania
10	Systems-oriented topics: Computer Vision Applications – Parking Lot Availability Recognition	ULBS-Romania
11	Process-oriented topics: Modeling and simulation-based design and optimization of manufacturing systems and processes on the ADOxx platform	ULBS-Romania
12	Systems-oriented topics: Petri Nets based automation of manufacturing systems	ULBS-Romania
13	Process-oriented topics: Service Operations Management	UNIBG-Italy
14	Process-oriented topics: Business Process Reengineering	UNIBG-Italy
15	Process-oriented topics: Fundamentals of Business Process Management (BPM)	UNIBIAL-Poland
16	Process-oriented topic: Robotics application in Virtual Laboratory	UNIOULU-Finland

5.1 Training courses provided by EMSE

Ecole Nationale Supérieure des Mines de Saint Etienne (EMSE) provides the following training components (Figure 3)

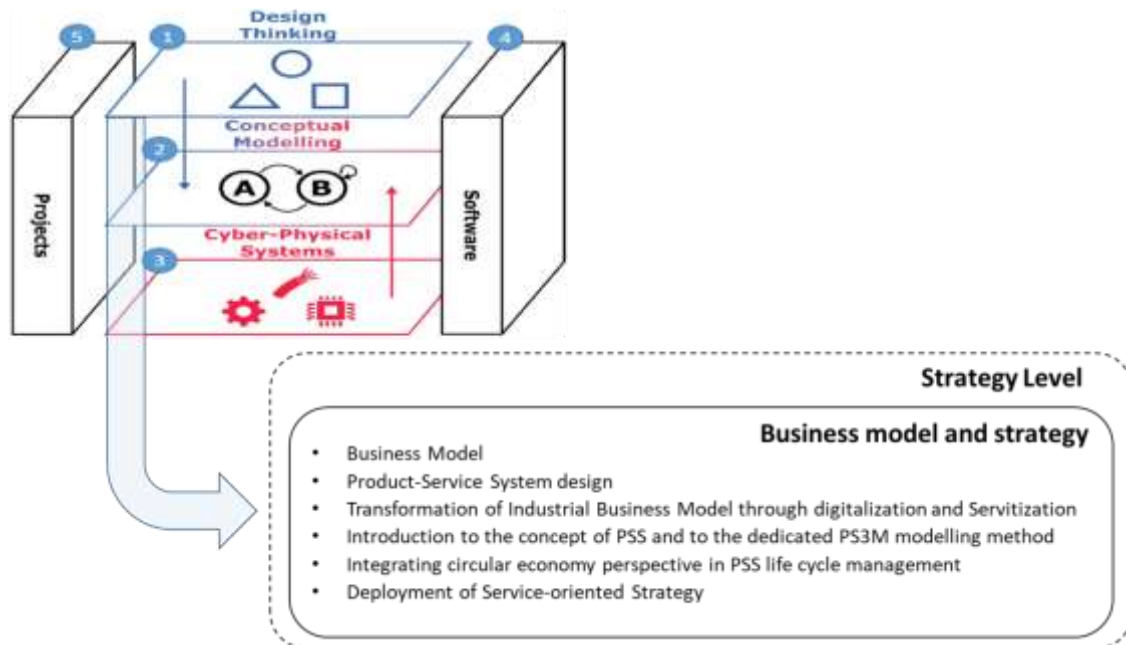


Figure 3.

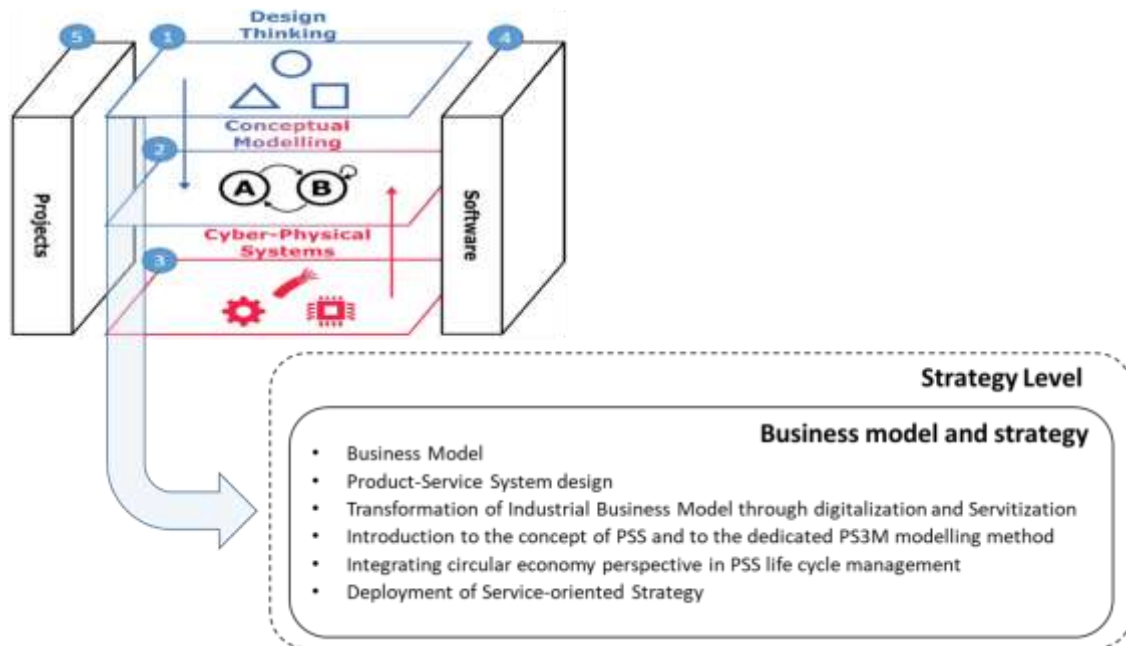


Figure 3 Training courses provided by EMSE

The details of each course are presented in the following sections.

5.1.1. Strategy-oriented topics: Business Model

Training specification	Explanation
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Training specification	Explanation
Organizer	EMSE France
Training Topic	Strategy-oriented topics: Customer-orientation. Imagine its services associated with its products
Training objectives	The training allows the company's employees to create product-related service ideas and test them before implementing a deployment plan.
Method	Stage 1-Empathy: Understanding the human needs involved Stage 2-Definition: Reconstructing and defining problems in a human-centric manner Stage 3-Ideate: Making many creative ideas in the conception session Stage 4-Prototyping: Practicing method in a Prototype Stage 5-Testing (Proposing prototypes/solutions to the problem): this stage could be postponed outside the training)
Target groups	Professionals of the same company
Recommended composition	Mix of jobs, abilities, gender, work experience
Recommended size of groups	Less than 10
Training duration	3 hours to 6 hours on the same day or on 2 separate days
Mode of tutoring	Design thinking
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Tools of Design Thinking
Recommended preparation	Having some information about the company, its strategy, its activity
Modes of working in teams	Playing roles, open mind for creativity
Communication and cooperation mode	Word documents; Empathy Map; Persona; Feasibility Roadmap
Necessary abilities to tackle the tasks of open problems	Group working skills, Presentation skills
Knowledge prerequisites	Product-Service System

5.1.2. Strategy-oriented topics: Product-Service System design

Training specification	Explanation
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Training specification	Explanation
Organizer	EMSE France
Training Topic	Strategy-oriented topics: Product-Service System Design
Training objectives	<ul style="list-style-type: none"> ▪ Understand and apply a method for the design of product service Systems ▪ Acquire operational skills on the use of a PSS modelling toolkit (PS3M), dedicated to design support
Method	<ul style="list-style-type: none"> ▪ Case study ▪ Practical work in team ▪ Model creation (PS3M modelling toolkit)
Target groups	<ul style="list-style-type: none"> ▪ Vocational training : professional of system design ▪ Master students (Industrial engineering and management)
Recommended composition	Various industrial cultures (production, marketing, design)
Recommended size of groups	10 to 20
Training duration	12 hours
Mode of tutoring	Expert input + Practical case study animation
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Computer Room with PS3M modelling toolkit
Recommended preparation	Read a case study
Modes of working in teams	Collective work with distributed role
Communication and cooperation mode	Informal communication
Necessary abilities to tackle the tasks of open problems	Creativity in system design, Coordination and communication abilities
Knowledge prerequisites	Introduction on PSS innovation and servitization

5.1.3. Strategy-oriented topics: Transformation of Industrial Business Model through digitalization and Servitization

Training specification	Explanation
Organizer	EMSE France
Training Topic	Transformation of Business Model through digitalization and servitization

Training specification	Explanation
Training objectives	Introduction to business model concept and tools Impacts of digitalization and servitization on business models Case study
Method	Lecture and case study
Target groups	Students or professionals
Recommended composition	Only students or only professionals, from the same company or from different companies
Recommended size of groups	20 max
Training duration	1,5h (lecture) +6h (case study)
Mode of tutoring	Lecture and case study
Mode of provision	Lecture and case study
Tools and resources to be used (technological-support tools)	Traditional (PPT)
Recommended preparation	Not necessary
Modes of working in teams	The case study is realized in groups of 2-3 (students or professionals)
Communication and cooperation mode	
Necessary abilities to tackle the tasks of open problems	
Knowledge prerequisites	None

5.1.4. Strategy-oriented topics: Introduction to the concept of PSS and to the dedicated PS3M modelling method

Training specification	Explanation
Organizer	EMSE France
Training Topic	Introduction to the concept of PSS and to the dedicated PS3M modelling method
Training objectives	Understand the concept of Product System Service, and how the usual product design method and practices have to change. Discover and experiment a PSS dedicated modelling tool (PS3M) and design method
Method	- Introductory lecture to provide all required conceptual notions on PSS

Training specification	Explanation
	<ul style="list-style-type: none"> - Introductory lecture to explain the conceptual and methodological structure of a PSS design method - Practical PSS design case study executed on the PS3M modelling tool
Target groups	PhD Students, (NEMO Summer School)
Recommended composition	If possible mix between PhD students from engineering and managerial sciences
Recommended size of groups	30 persons, by groups of 2 or for the practical case study
Training duration	3h
Mode of tutoring	1h : lecture 2h : Case study animation with PSS Design Tool (PS3M)
Mode of provision	Lecture can be on distance. Case study with physical teaching.
Tools and resources to be used (technological-support tools)	Computer room, with installation of PS3M software.
Recommended preparation	Installation of software Download of case study computer data and import of data within PS3M If possible anticipatory lecture of general paper on PSS.
Modes of working in teams	Collaborative problem-solving
Communication and cooperation mode	/
Necessary abilities to tackle the tasks of open problems	Problem analysis, Problem-solving abilities, Synthesis
Knowledge prerequisites	Modelling abilities.

5.1.5. Strategy-oriented topics: Integrating circular economy perspective in PSS life cycle management

Training specification	Explanation
Organizer	EMSE France
Training Topic	Integrating circular economy perspective in PSS life cycle management
Training objectives	<ul style="list-style-type: none"> • Product-Service System (PSS) • Circular Economy • Role of PSS in circular economy implementation • Adopting a systems approach in PSS life cycle management (PSS lifecycle based on circular economy)

Training specification	Explanation
Method	<ul style="list-style-type: none"> • Theoretical background teaching • Case study • Project-Based learning
Target groups	Master Students
Recommended composition	Students from various engineering background Professionals from industry
Recommended size of groups	10 to 30
Training duration	12 hours (50% lecture, 50% project)
Mode of tutoring	Literature review, industrial cases review, Practical case study animation
Mode of provision	Teaching and workshop
Tools and resources to be used (technological-support tools)	No need for a special technological support
Recommended preparation	Read industrial cases and think about a solution
Modes of working in teams	Collective work
Communication and cooperation mode	Informal communication
Necessary abilities to tackle the tasks of open problems	Design thinking
Knowledge prerequisites	No prerequisites required

5.1.6. Strategy-oriented topics: Deployment of Service-oriented Strategy

Training specification	Explanation
Organizer	EMSE France
Training Topic	Interactive training with small and medium size industrial companies, to initiate a service-oriented strategy.
Training objectives	The objective is to bring various complementary competencies of the company, to work collaboratively on both strategic diagnosis and perspective development, so as to identify key strategical factors and incentive/resistance for service development, and key opportunities for initiating the transition.
Method	A structured framework is proposed, for various diagnosis steps : <ul style="list-style-type: none"> - Service-oriented strategical context analysis; - Service opportunities analysis, through business sectors - Collective competence transformation anticipation

Training specification	Explanation
	- Proposal of service development trajectory
Target groups	Vocational training: each training is dedicated to only one company. SMI companies with, a first contact with service activities, and an ambition to further develop service-oriented strategies
Recommended composition	Each group should gather actors from the key functions involved in product-service innovation in the companies, like top management board, marketing, sales management, system design and development, production, after sale services, customer relationship management.
Recommended size	15 persons
Training duration	2 days (4 half-day courses during 2 month)
Mode of tutoring	The seminar is full interactive diagnosis process, applied to the internal data of the company. The 2 days of training include three half-days in direct interaction with the actors for interview and information capture + one half-day of final debriefing and interaction. Additionally, the animators have to work 'off-line' additionally to the 2 training days on information analysis, synthesis and diagnosis.
Mode of provision	Interactive academic/industrial diagnosis process
Tools and resources to be used (technological-support tools)	Structured diagnosis methodology, including audit and diagnosis tools at different steps.
Recommended preparation	Top management of the company should be involved and should act as sponsor of the training. A preliminary awareness-raising on product-Service innovation strategies should be delivered to company staff.
Modes of working in teams	Collective problem analysis and solving. Collective creativity
Communication and cooperation mode	Physical interaction
Necessary abilities to tackle the tasks of open problems	Creativity, Innovation, Context analysis, Design thinking, System thinking.
Knowledge prerequisites	A preliminary awareness-raising on product-Service innovation strategies should be delivered to company staff.

5.2 Training courses provided by ULBS

Lucian Blaga University of Sibiu (ULBS) provides the following training units (Figure 4).

- Workplace safety – Employees emotion recognition (Monitor a machine operator and detect the operator's emotional state. Send an alert if the operator is distracted or angry).
- Computer Vision for Manufacturing Industry Application
- Modeling and simulation-based design and optimization of manufacturing systems and processes on the ADOxx platform

- Petri Nets based automation of manufacturing systems
- Sibiu – Smart city modeling (ADOxx)
- Computer Vision Applications: Parking Lot Availability Recognition

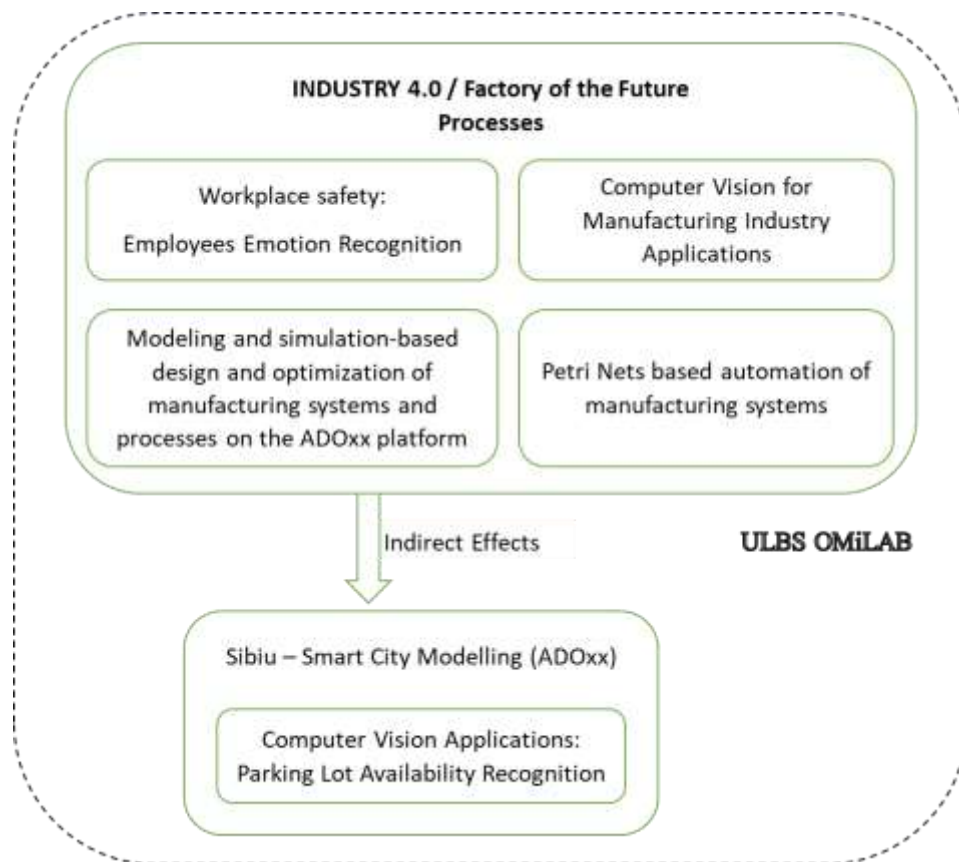


Figure 4 Training courses provided by ULBS

The details of each course are presented in the following sections.

5.2.1. Strategy-oriented topics: Sibiu – Smart City Modelling

Training specification	Explanation
Organizer	ULBS, Romania
Training Topic	<p>Sibiu – Smart City Modelling</p> <p>Smart city modelling becomes a necessity and represents an indirect effect of Industry 4.0 revolution. The industrial evolution has both benefits (increasing wellbeing) and drawbacks (city crowding). The level of welfare of many families can be measured by the number of owned cars; in many cases, the number more than one. But this means much more traffic which includes the public and heavy goods transport, creating congestion and, finally, air and noise pollution. Also, parking space and other infrastructure problems are the consequence of city crowding.</p> <p>For educational and demonstration purposes the OMILAB Package contains three demonstration scenarios, in line with the architecture of the Evaluation Space. The third Demonstration Scenario links all three architectural layers - the Business Layer, the Conceptual Modelling Layer and the Proof of Concept Layer - together in a Smart City/Smart</p>

Training specification	Explanation
	Parking teaching example. It employs the mBot on the CPS-Proof of Concept Layer and the SAP Scenes figures on the Business Layer as well as all modelling tools.
Training objectives	<ul style="list-style-type: none"> ▪ Understand and apply a method for the design of smart city modelling ▪ Acquire operational skills on the use of ADOxx toolkits for Smart City modelling
Method	<ul style="list-style-type: none"> ▪ Case study ▪ Practical work in team ▪ Model creation
Target groups	<ul style="list-style-type: none"> ▪ Vocational training: professional of system design ▪ Master students
Recommended composition	Various industrial cultures (production, marketing, design)
Recommended size of groups	10 to 20
Training duration	12 hours
Mode of tutoring	Expert input + Practical case study animation
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Computer Room with ADOxx modelling toolkit
Recommended preparation	Read a smart city case study
Modes of working in teams	Collective work with distributed role
Communication and cooperation mode	Informal communication
Necessary abilities to tackle the tasks of open problems	Creativity in system design, Coordination and communication abilities
Knowledge prerequisites	Smart City challenges

5.2.2. Systems-oriented topics: Workplace safety – Employees emotion recognition

Training specification	Explanation
Organizer	ULBS, Romania
Training Topic	Workplace safety – Employees emotion recognition
Training objectives	<ul style="list-style-type: none"> • Understand how emotions affect risk perception and behavior • Understand, design and implement a method to recognize

Training specification	Explanation
	human emotions from live video sequences
Method	<ul style="list-style-type: none"> • Case study: losing control of your emotions means losing control of your safety • Work in teams
Target groups	<ul style="list-style-type: none"> • Master students (Computer Science) • Software engineers
Recommended composition	Individuals with basic programming knowledge
Recommended size of groups	10 to 15
Training duration	12 hours
Mode of tutoring	Expert input + practical case study
Mode of provision	Workshop / Classroom
Tools and resources to be used (technological-support tools)	Computer room with Java/Python or C# installed
Recommended preparation	Get familiar with OpenCV
Modes of working in teams	Collective work with distributed role
Communication and cooperation mode	Informal communication
Necessary abilities to tackle the tasks of open problems	Ability to work in team
Knowledge prerequisites	Basic programming knowledge

5.2.3. Systems-oriented topics: Computer Vision for Manufacturing Industry Application

Training specification	Explanation
Organizer	ULBS, Romania
Training Topic	Vocational training on Computer Vision for Manufacturing Industry Application

Training specification	Explanation
Training objectives	<ul style="list-style-type: none"> ▪ Knowledge of the basic and common algorithms ▪ Understanding the phases of image processing for product control ▪ Skills for future implementation of computer vision manufacturing control points
Method	<ul style="list-style-type: none"> ▪ Algorithms and tools ▪ Case studies on different images from production lines ▪ Practical work in team
Target groups	<ul style="list-style-type: none"> ▪ Vocational training: professionals on quality and control systems ▪ Master students (Advanced Computing Systems)
Recommended composition	Various industrial cultures (production, programming, control and testing)
Recommended size of groups	10 to 15
Training duration	4 hours to 6 hours on the same day or on 2 separately days
Mode of tutoring	Presentation, practical image processing
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Computer room with MATLAB
Recommended preparation	Basic knowledge of image processing
Modes of working in teams	Individual work and collaborative
Communication and cooperation mode	Informal communication
Necessary abilities to tackle the tasks of open problems	Programming skills
Knowledge prerequisites	Image processing

5.2.4. Systems-oriented topics: Computer Vision Applications – Parking Lot Availability Recognition

Training specification	Explanation
Organizer	ULBS, Romania
Training Topic	Computer Vision Applications: Parking Lot Availability Recognition

Training specification	Explanation
Training objectives	<ul style="list-style-type: none"> ▪ Knowledge of the basic and common algorithms in image processing ▪ Understanding the phases of image processing for feature detection and recognition ▪ Skills for future implementation of computer vision applications
Method	<ul style="list-style-type: none"> ▪ Algorithms and tools ▪ Case studies on different images from parking lot cameras ▪ Practical work in small teams
Target groups	<ul style="list-style-type: none"> ▪ Vocational training: professionals on automation ▪ Master students (Advanced Computing Systems)
Recommended composition	Various industrial cultures (production, programming, control and testing)
Recommended size of groups	10 to 15
Training duration	4 hours to 6 hours on the same day or on 2 separately days
Mode of tutoring	Presentation, practical image processing
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Computer Room with MATLAB
Recommended preparation	Basic knowledge of image processing
Modes of working in teams	Individual work
Communication and cooperation mode	Informal communication
Necessary abilities to tackle the tasks of open problems	Programming skills
Knowledge prerequisites	Image processing

5.2.5. Process-oriented topics: Modeling and simulation-based design and optimization of manufacturing processes on the ADOxx platform

Training specification	Explanation
Organizer	ULBS, Romania
Training Topic	Modeling and simulation-based design and optimization of manufacturing systems and processes on the ADOxx platform

Training specification	Explanation
Training objectives	<ul style="list-style-type: none"> ▪ Understand and apply methods for the design of manufacturing systems and processes ▪ Understand and apply methods for the optimization of manufacturing systems operation ▪ Acquire operational skills on the use of ADOxx toolkits for domain specific metamodeling ▪ Acquire operational skills on the use of ADOxx toolkits manufacturing systems modelling and simulation
Method	<ul style="list-style-type: none"> ▪ Case studies ▪ Metamodeling stage – the participants define together a Domain Specific Language that best describe the domain of the studied cases, On its bases they build the modeling and simulation tools ▪ Modelling stage – grouped in team the participants compete in solving manufacturing systems design problem. They must design a system producing a given product assortment ▪ Simulation stage – grouped in teams the participant compete in solving manufacturing system operation problems, They must find the best schedule for a given product assortment
Target groups	<ul style="list-style-type: none"> ▪ Master students
Recommended composition	Various specialization (IT, mechatronics, process)
Recommended size of groups	12 to 20 (3 to5 teams of 4)
Training duration	16 hours
Mode of tutoring	Guiding the discussion Design thinking Moderating the AfterAction report
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Computer Room with ADOxx modelling toolkit
Recommended preparation	Forming the interdisciplinary teams Domain familiarizing lecture
Modes of working in teams	Competing teams
Communication and cooperation mode	Informal communication Team work
Necessary abilities to tackle the tasks of open problems	Creativity in system design, Coordination and communication abilities, Problem solving abilities
Knowledge prerequisites	Knowledge in Enterprise architecture, Cyber Physical Systems , Production equipment, Manufacturing systems and processes

5.2.6. Systems-oriented topics: Training of Research Master Students on the Petri Nets based automation of manufacturing systems

Training specification	Explanation
Organizer	ULBS, Romania
Training Topic	Petri Nets based automation of manufacturing systems
Training objectives	<ul style="list-style-type: none"> ▪ Understand and apply a method for designing robust and deadlock free control solution for manufacturing systems ▪ Acquire operational skills on the use of Petri Nets tools for automation
Method	<ul style="list-style-type: none"> ▪ Stage 1 The students learn to model the plants and the automation system using the Petri net using a mix of think-pair-share and problem solving ▪ Stage 2 The students learn to express the automated system specification as Petri Net properties that must be satisfied using a mix of case studies and problem solving ▪ Stage 3 The students solve problems of a manufacturing system automation
Target groups	<ul style="list-style-type: none"> ▪ Master students
Recommended composition	Interdisciplinary (IT specialists, Automatists, Cyber Physical Systems engineers, Process engineers)
Recommended size of groups	12 to 20 (3 to 5 teams of 4)
Training duration	16 hours
Mode of tutoring	Case studies animation Active probing Problem presentation After Action Report animation
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Computer Room with Petri Net tools
Recommended preparation	Forming the interdisciplinary teams Domain familiarizing lecture
Modes of working in teams	Think-pair-share Competing teams
Communication and cooperation mode	Informal communication Problem solving abilities Team work
Necessary abilities to tackle the tasks of open problems	Coordination and communication abilities Problem solving
Knowledge prerequisites	Automatic control of processes Manufacturing processes

5.3 Training courses provided by UNIBG

University of Bergamo (UNIBG) provides the following training units (Figure 5).

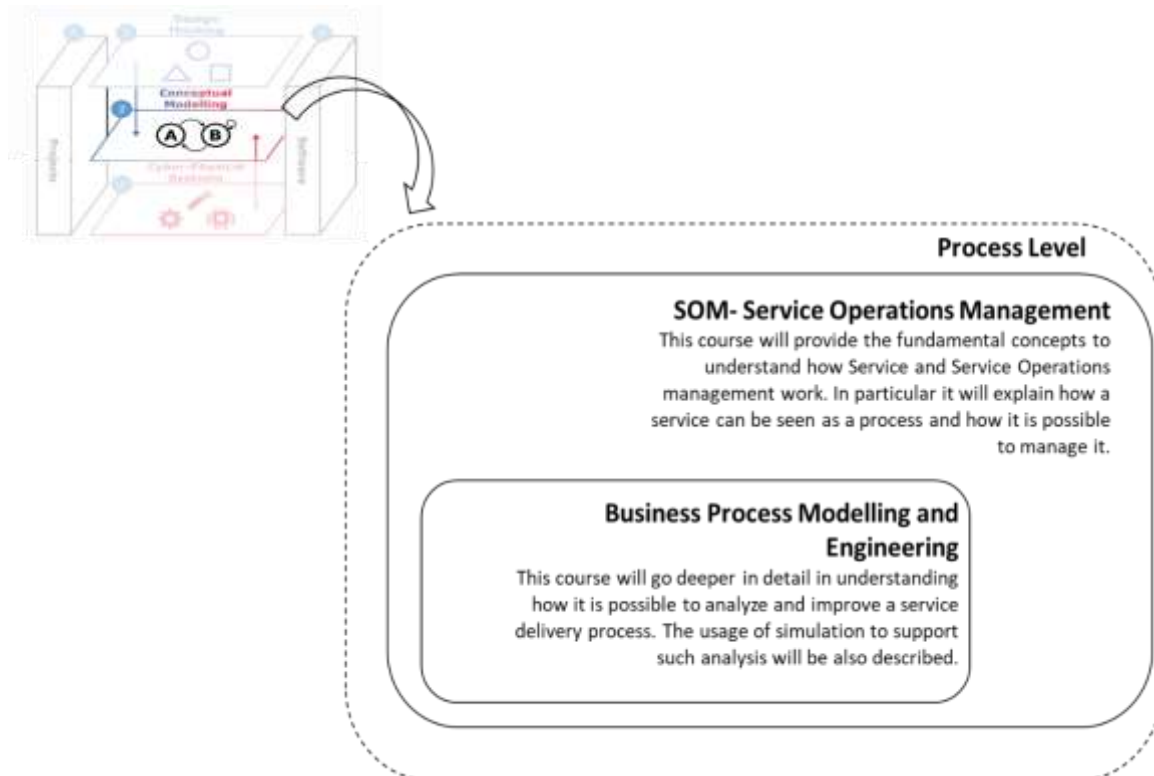


Figure 5 Training courses provided by UNIBG

The details of each course are presented in the following sections.

5.3.1. Process-oriented topic: Service Operations Management

Training specification	Explanation
Organizer	UNIBG Italy
Training Topic	Process-oriented topic: Service Operations Management
Training objectives	Process-oriented topic: The training allows the company's employees to understand the main concept of service, analyze in the associated processes and get to know the main techniques to classify and model them.
Method	<ul style="list-style-type: none"> • Case study • Team working • Business process modelling
Target groups	Engineering professionals or master students
Recommended composition	Mix of jobs, abilities, gender, work experience

Training specification	Explanation
Recommended size of groups	Between 10 and 20
Training duration	6 hours
Mode of tutoring	Expert input + Practical case study animation
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Tools and languages for process modeling
Recommended preparation	none
Modes of working in teams	Collective with distributed roles
Communication and cooperation mode	Informal communication
Necessary abilities to tackle the tasks of open problems	Creativity, Group working and collaborative skills
Knowledge prerequisites	None

5.3.2. Process-oriented topic: Business Process Modeling and Reengineering

Training specification	Explanation
Organizer	UNIBG Italy
Training Topic	Process-oriented topic: Business Process Modeling and Reengineering. Understand how to represent and improve a business process
Training objectives	The training allows the company's employees to explore the main methods and tools to analyze and improve business processes. Trainings on simulation techniques to develop what ifs analysis will be also proposed.
Method	<ul style="list-style-type: none"> • Team working • Practical case study • Modelling exercise • Process improvement through “what-if analysis” and simulation
Target groups	Professionals or master students
Recommended composition	Mix of jobs, abilities, gender, work experience
Recommended size of groups	Between 10 and 15

Training specification	Explanation
Training duration	12 hours
Mode of tutoring	Expert input + Practical case study to be analyzed through simulation
Mode of provision	Workshop
Tools and resources to be used (technological-support tools)	Modelling tools and simulation software
Recommended preparation	none
Modes of working in teams	Group working
Communication and cooperation mode	Informal communication and shared documents and models
Necessary abilities to tackle the tasks of open problems	Group working skills
Knowledge prerequisites	Basic features of business processes

5.4 Training courses provided by UNIBIAL

Bialystok University of Technology (UNIBAL) provides the following training units (Figure 6).

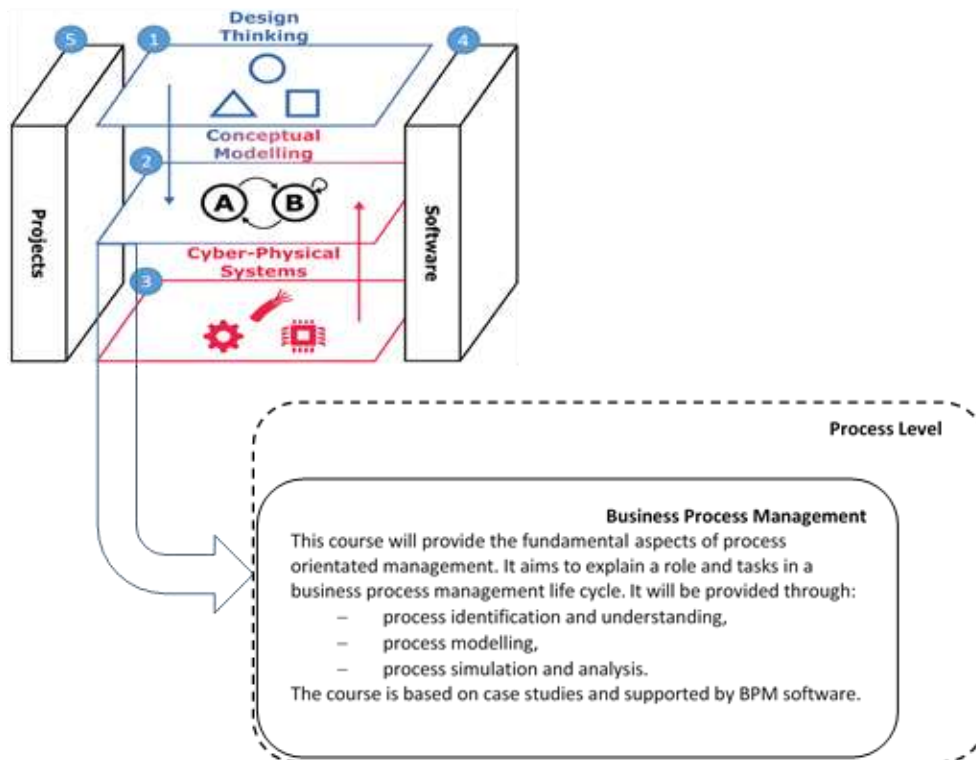


Figure 6 Training courses provided by UNIBIAL

The details of each course are presented in the following sections.

5.4.1. Process-oriented topic: Fundamentals of Business Process Management (BPM)

Training specification	Explanation
Organizer	Bialystok University of Technology, Poland
Training Topic	Process-oriented topic: Fundamentals of Business Process Management (BPM)
Training objectives	Understanding the key aspects of BPM in the enterprise. Hands-on learning process design, acquiring knowledge and skills in the principles of analysis, modelling and documentation processes. Developing creativity and contextual thinking.
Method	Stage 1 – Principles of process orientation Stage 2 – Rules of BPM Stage 3 – “As-is” process analysis and modelling Stage 4 – “To-be” process analysis and designing Stage 5 – Reports and recommendations
Target groups	Professionals of the same or different companies
Recommended composition	Mix of jobs, abilities, gender, work experience
Recommended size of groups	Less than 10 persons
Training duration	4 hours to 8 hours on the same day or on 2 separately days
Mode of tutoring	Lecture, Case method
Mode of provision	Workshop/laboratory-based training
Tools and resources to be used (technological-support tools)	IT tools for BPM
Recommended preparation	Understanding of business management fundamentals
Modes of working in teams	Collaborative problem-solving, Team/individual Q&A
Communication and cooperation mode	Process maps and models, Reports, Charts
Necessary abilities to tackle the tasks of open problems	Critical analysis, Group working skills
Knowledge prerequisites	Fundamentals of organization/business unit management

5.5 Training courses provided by UNIOULU

University of Oulu (UNIOULU) provides the following training units.

5.5.1. Process-oriented topic: Robotics application in Virtual Laboratory

Training specification	Explanation
Organizer	University of Oulu (UNIOULU) Finland
Training Topic	Process-oriented topic: Robotics application in Virtual Laboratory
Training objectives	Have knowledge of robotics process conceptual modelling based on ADOxx platform Be capable of implementing some hands-on tools (adopting Bee-up) to design the models Get the basic ideas how robots cooperate in the real settings Cultivate more sense of robotics
Method	Modelling practice case study
Target groups	Vocational training: professionals on automation Master students (Advanced Computing Systems)
Recommended composition	Mix of jobs, abilities, gender, work experience
Recommended size of groups	Less than 10 people
Training duration	2 days
Mode of tutoring	Lecture, case study
Mode of provision	Workshop/laboratory-based training
Tools and resources to be used (technological-support tools)	Modelling tools
Recommended preparation	Basic knowledge about modelling and robotics
Modes of working in teams	Group discussion
Communication and cooperation mode	Informal communication Problem solving capacities
Necessary abilities to tackle the tasks of open problems	Problem solving
Knowledge prerequisites	Basic knowledge about robotics

6 Conclusion

Deliverable 3.1 has presented the training subjects that the project will provide to equip the academia and industry with the necessary skills for Factory of Future. Three

layers of training proposed by the project are Strategy-, Process-, and Systems-oriented subjects. These subjects are divided into deliverable training courses thought by different partners of the project. Each partner will create and realize training courses in their competence domain.

In order to evaluate the training courses, the evaluation templates from D6.1 will be used (Appendix I).

References

Johnstone, Karla M., and Stanley F. Biggs. "Problem-based learning: Introduction, analysis, and accounting curricula implications." *Journal of Accounting Education* 16.3-4 (1998): 407-427.

Wyness, Lynne, and Fiona Dalton. "The value of problem-based learning in learning for sustainability: Undergraduate accounting student perspectives." *Journal of Accounting Education* 45 (2018): 1-19.

Appendix I

Annexes from D6.1 for training evaluation

ANNEX B: List of event attendees



Event	
Venue	
Date	
Organisers	

ATTENDEES:

	Name	Organisation	Signature
1			
2			
3			
4			
5			
6			
7			
8			
9			
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11			
12			
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15			

ANNEX C: Participant feedback form

Dear Participant,

Thank you for attending this event. In order to improve the organisation of the events within the DigiFoF project, we invite you to complete the following questionnaire.

We appreciate your valuable contribution and we thank you in advance!

	Most satisfied	Satisfied	Moderately satisfied	Rather dissatisfied	Not at all satisfied
Overall organisation of the event	5	4	3	2	1
Programme structure	5	4	3	2	1
Time management	5	4	3	2	1
Venue and facilities	5	4	3	2	1
Presentations	5	4	3	2	1
Interaction with other participants	5	4	3	2	1

Please indicate your agreement with the following statements

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The information I got will be useful for my job	5	4	3	2	1
The topics of the event are similar to what I was expecting	5	4	3	2	1
The material distributed is useful and informative	5	4	3	2	1
The overall structure of the event is suitable for the topic and the participants	5	4	3	2	1
The style and the communication of the organisers is suitable for this kind of event	5	4	3	2	1
The interaction between organisers and participants was relevant	5	4	3	2	1
I would recommend this kind of event to colleagues	5	4	3	2	1

Additional comments:

ANNEX D: Event report template

Author:	
Event Title:	
Event Date and Venue:	
Type of event (training, webinar, summer school):	
Organiser(s):	
Link to Agenda:	
Short description:	
Total number of participants invited:	
Total number of participants:	

EVENT ROLLOUT

Please attach the final event agenda and the list of participants (Annex B)

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EVENT EVALUATION BY PARTICIPANTS

Summary of the Participant Feedback Form

Please insert the results of the feedback received from participants. Include only the overall percentage of the feedback received.

	Most satisfied	Satisfied	Moderately satisfied	Rather dissatisfied	Not at all satisfied
Overall organisation of the event					
Programme structure					
Time management					
Venue and facilities					
Presentations					
Interaction with other participants					