**Project Title:**
THE FOF-DESIGNER:
DIGITAL DESIGN SKILLS FOR FACTORIES OF THE FUTURE

**Project Acronym:**
**DigiFoF**

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D.3.1. Problem-based learning path for students and professionals

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EMSE

**Project Coordinator:**
ULBS

**Contributors:**
All Partners

**Reviewers:**
SOCOLNET

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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<br>-Facilitating discussion | Interactively discussing the case in small groups |
| Modified case-based method | Complex case containi*ng* initial representation of the problem is provided *prior to lecture* | -Giving little or no lecture<br>-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<br>-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<br>-Reviewing technical knowledge that applies to the present case. | - Re-evaluating the case after completion<br>-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.<br>-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

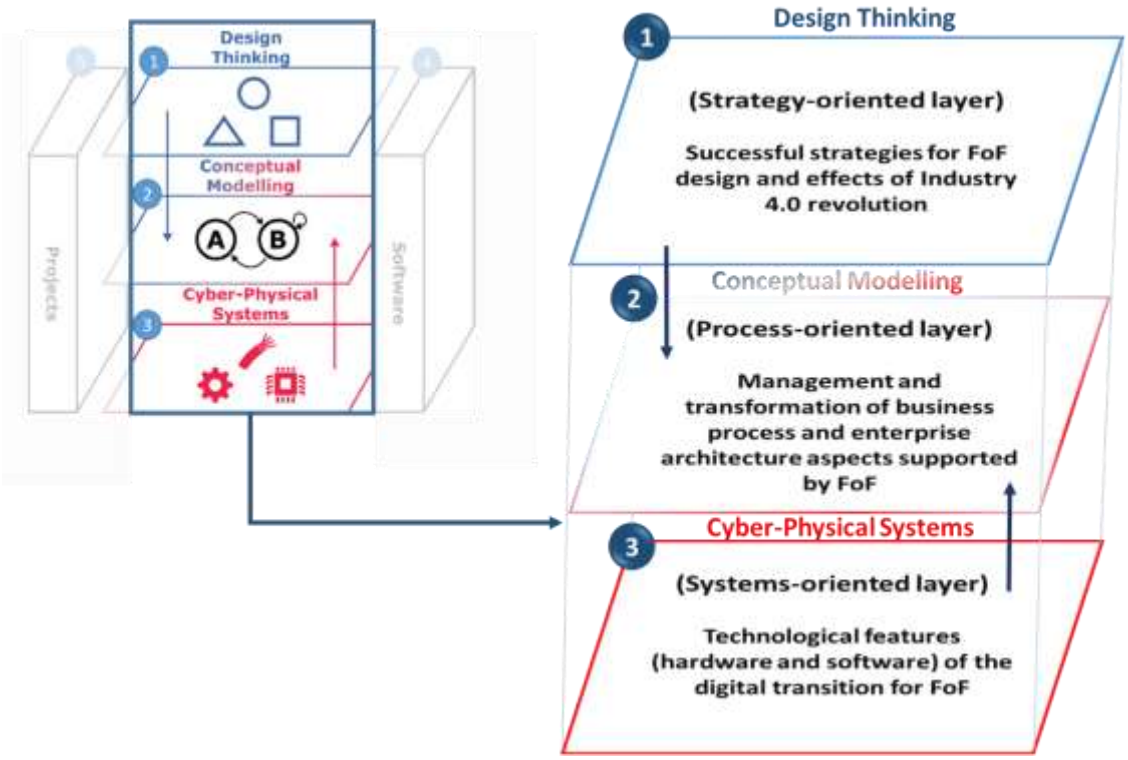


*Figure 1 OMiLAB DigiFoF training topics*

## *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) | ▪ Vocational training on Service Delivery Process Management<br>▪ Vocational training on PSS design and Business Models<br>▪ Training of master students on Business Process Reengineering<br>▪ Training of research master students on Meta-modelling through ADOxx platform |

| OMiLAB4FoF Laboratories | educational applications |
|---|---|
| | ▪ Training of master students on PSS design method and tool |
| OMILAB Italy (UNIBG) | ▪ Vocational training on the identification of innovative Product Service Systems (Adopting Scene2Model*).*<br>▪ Vocational training on the lifecycle management of products and services.<br>▪ Vocational trainings on Service Operations Management<br>▪ Vocational trainings on Business process analysis and re-engineering.<br>▪ Training of Master Students on Design thinking to develop new solutions.<br>▪ Training of Master Students on process modelling languages, tools and simulation. |
| OMILAB Romania (ULBS) | ▪ Training of Research Master Students on Smart city challenges – modeling with ADOxx<br>▪ Vocational training about Scene2model and Emotion Recognition for employees<br>▪ Vocational training about Machine Vision for Manufacturing Industry Application<br>▪ Image recognition applications: parking lot detection<br>▪ 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<br>▪ Training of Research Master Students on the Petri Nets based automation of manufacturing systems |
| OMILAB Poland (UNIBIAL) | Training of Master Students on Business Process Management, including:<br>▪ Business process identification and analysis;<br>▪ Business process modelling and analysis with Adonis and ADOxx;<br>▪ Business process simulation with Adonis. |
| OMILAB Finland (UNIOULU) | ▪ Vocational training about Bee-up model based on ADOxx platform<br>▪ Robotics application: e.g. non-oats detection<br>▪ Arm Robot and mobile Robot cooperation application<br>▪ Aerial Robot and mobile Robot cooperation application: fast delivery process<br>▪ 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).

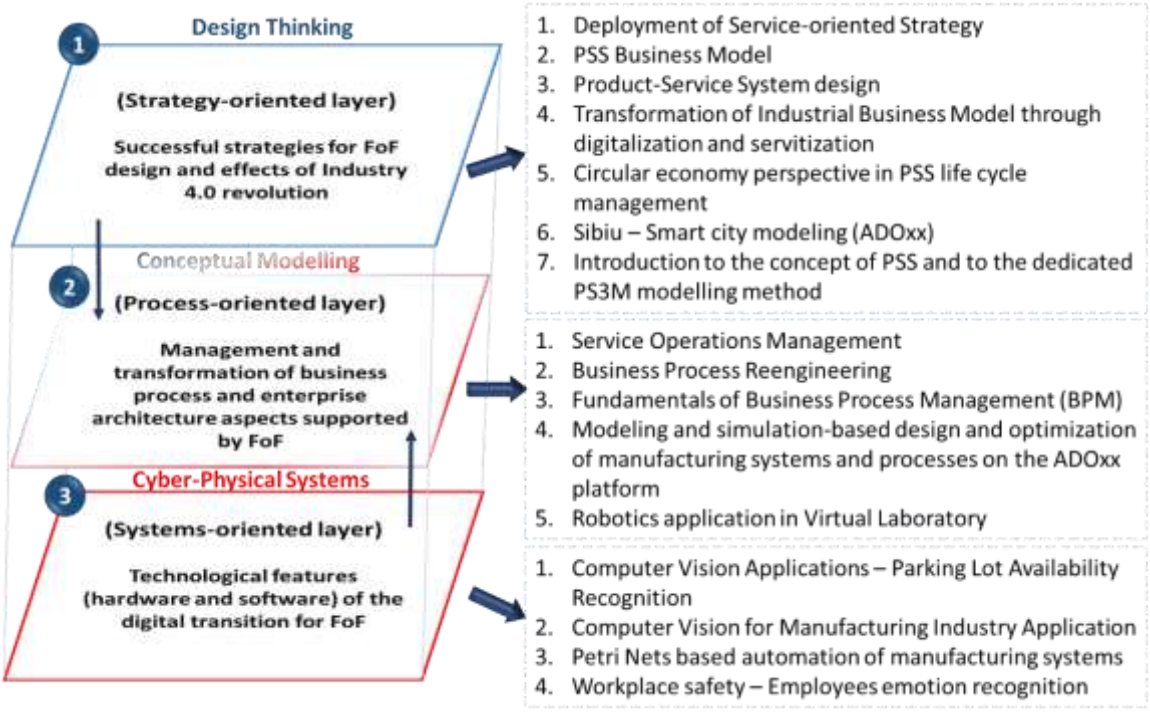


*Figure 2 Training courses provided by the project*

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)

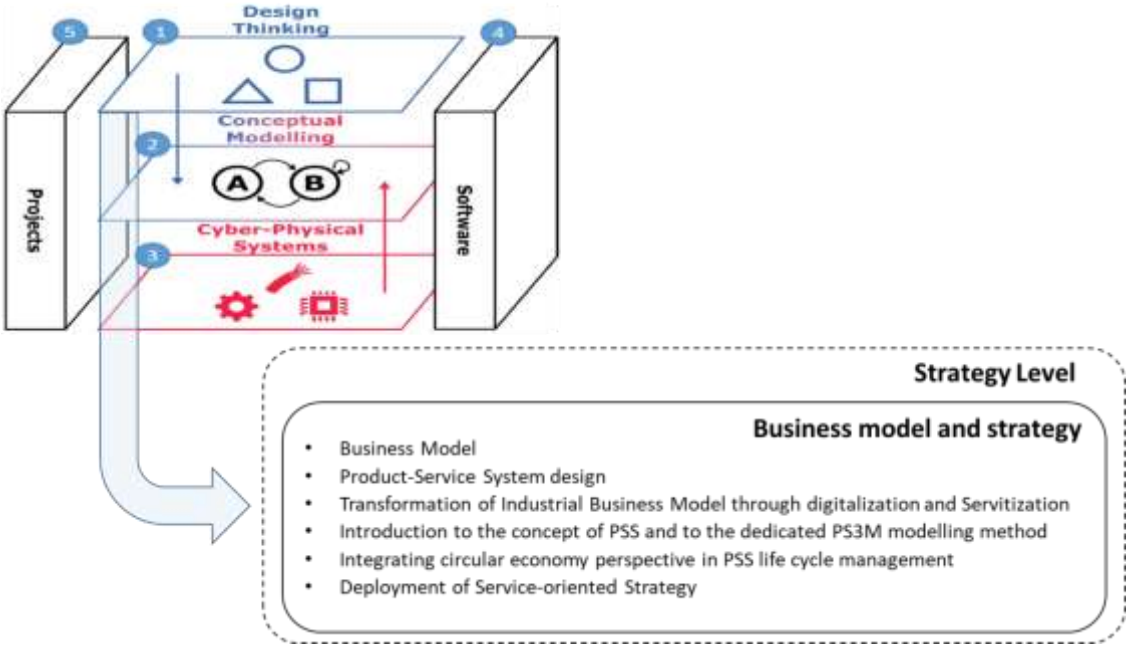


*Figure **3**.*

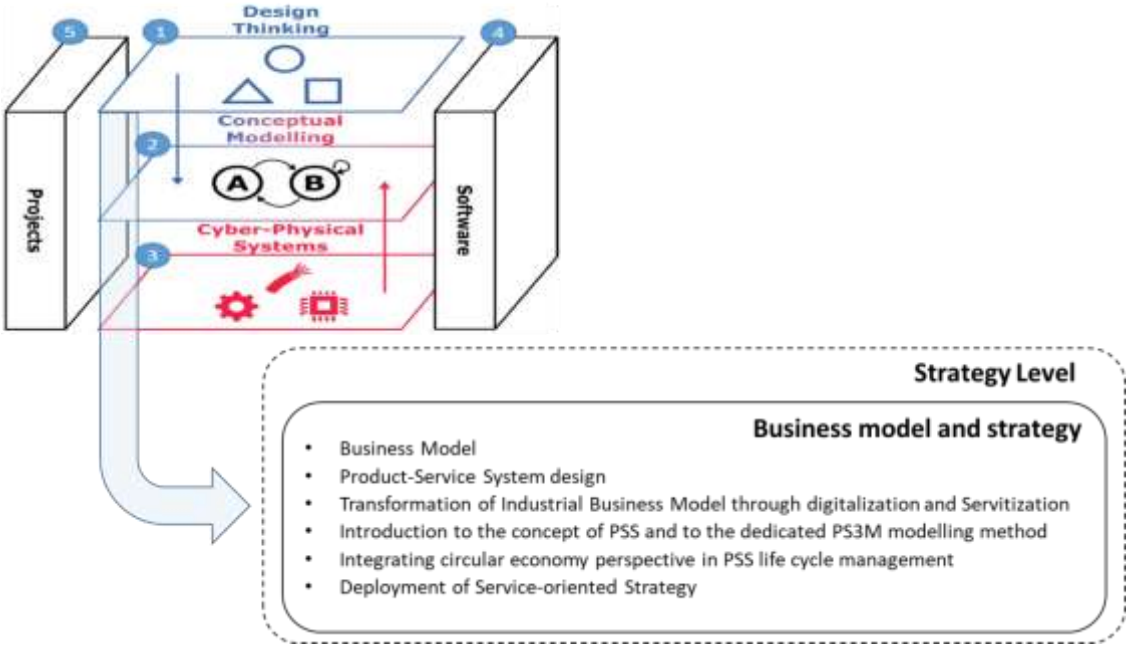


*Figure 3 Training courses provided by EMSE*

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

### 5.1.1. Strategy-oriented topics: Business Model

| Training specification | Explanation |
|---|---|

| 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<br>Stage 2-Definition: Reconstructing and defining problems in a human-centric manner<br>Stage 3-Ideate: Making many creative ideas in the conception session<br>Stage 4-Prototyping: Practicing method in a Prototype<br>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 |
|---|---|

| Training specification | Explanation |
|---|---|
| Organizer | EMSE France |
| Training Topic | Strategy-oriented topics: Product-Service System Design |
| Training objectives | ▪ Understand and apply a method for the design of product service Systems<br>▪ Acquire operational skills on the use of a PSS modelling toolkit (PS3M), dedicated to design support |
| Method | ▪ Case study<br>▪ Practical work in team<br>▪ Model creation (PS3M modelling toolkit) |
| Target groups | ▪ Vocational training : professional of system design<br>▪ 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<br>Impacts of digitalization and servitization on business models<br>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.<br>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 |
|---|---|
| | - Introductory lecture to explain the conceptual and methodological structure of a PSS design method<br>- 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<br>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<br>Download of case study computer data and import of data within PS3M<br>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 | • Product-Service System (PSS)<br>• Circular Economy<br>• Role of PSS in circular economy implementation<br>• Adopting a systems approach in PSS life cycle management (PSS lifecycle based on circular economy) |

| Training specification | Explanation |
|---|---|
| Method | • Theoretical background teaching<br>• Case study<br>• Project-Based learning |
| Target groups | Master Students |
| Recommended composition | Students from various engineering background<br>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 :<br>- Service-oriented strategical context analysis;<br>- Service opportunities analysis, through business sectors<br>- 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.<br>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.<br>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

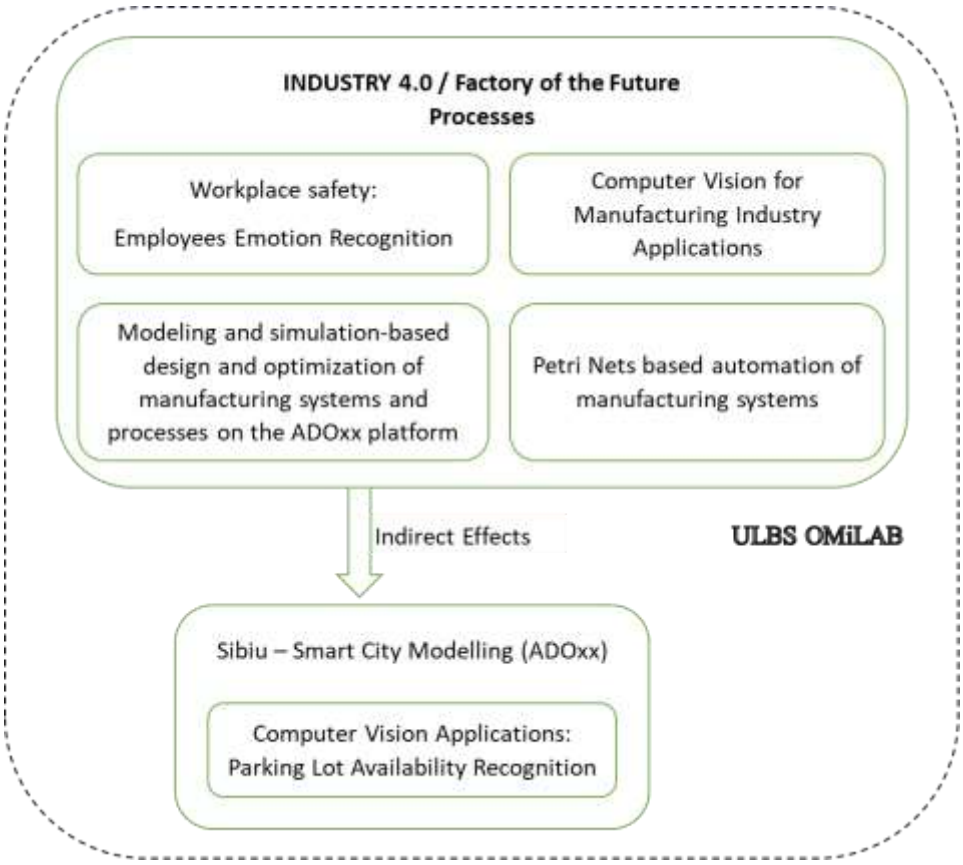


*Figure 4 Training courses provided by ULBS*

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 | Sibiu – Smart City Modelling<br>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.<br>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 |

| 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 | ▪ Understand and apply a method for the design of smart city modelling<br>▪ Acquire operational skills on the use of ADOxx toolkits for Smart City modelling |
| Method | ▪ Case study<br>▪ Practical work in team<br>▪ Model creation |
| Target groups | ▪ Vocational training: professional of system design<br>▪ 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 | • Understand how emotions affect risk perception and behavior<br>• Understand, design and implement a method to recognize |

| Training specification | Explanation |
|---|---|
| | human emotions from live video sequences |
| Method | • Case study: losing control of your emotions means losing control of your safety<br>• Work in teams |
| Target groups | • Master students (Computer Science)<br>• 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 | ▪ Knowledge of the basic and common algorithms<br>▪ Understanding the phases of image processing for product control<br>▪ Skills for future implementation of computer vision manufacturing control points |
| Method | ▪ Algorithms and tools<br>▪ Case studies on different images from production lines<br>▪ Practical work in team |
| Target groups | ▪ Vocational training: professionals on quality and control systems<br>▪ 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 | ▪ Knowledge of the basic and common algorithms in image processing<br>▪ Understanding the phases of image processing for feature detection and recognition<br>▪ Skills for future implementation of computer vision applications |
| Method | ▪ Algorithms and tools<br>▪ Case studies on different images from parking lot cameras<br>▪ Practical work in small teams |
| Target groups | ▪ Vocational training: professionals on automation<br>▪ 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 | ▪ Understand and apply methods for the design of manufacturing systems and processes<br>▪ Understand and apply methods for the optimization of manufacturing systems operation<br>▪ Acquire operational skills on the use of ADOxx toolkits for domain specific metamodeling<br>▪ Acquire operational skills on the use of ADOxx toolkits manufacturing systems modelling and simulation |
| Method | ▪ Case studies<br>▪ 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<br>▪ Modelling stage – grouped in team the participants compete in solving manufacturing systems design problem. They must design a system producing a given product assortment<br>▪ 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 | ▪ 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<br>Design thinking<br>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<br>Domain familiarizing lecture |
| Modes of working in teams | Competing teams |
| Communication and cooperation mode | Informal communication<br>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 | ▪ Understand and apply a method for designing robust and deadlock free control solution for manufacturing systems<br>▪ Acquire operational skills on the use of Petri Nets tools for automation |
| Method | ▪ 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<br>▪ 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<br>▪ Stage 3 The students solve problems of a manufacturing system automation |
| Target groups | ▪ Master students |
| Recommended composition | Interdisciplinary (IT specialists, Automatists, Cyber Physical Systems engineers, Process engineers) |
| Recommended size of groups | 12 to 20 (3 to5 teams of 4) |
| Training duration | 16 hours |
| Mode of tutoring | Case studies animation<br>Active probing<br>Problem presentation<br>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<br>Domain familiarizing lecture |
| Modes of working in teams | Think-pair-share<br>Competing teams |
| Communication and cooperation mode | Informal communication<br>Problem solving abilities<br>Team work |
| Necessary abilities to tackle the tasks of open problems | Coordination and communication abilities<br>Problem solving |
| Knowledge prerequisites | Automatic control of processes<br>Manufacturing processes |

## *5.3 Training courses provided by UNIBG*

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

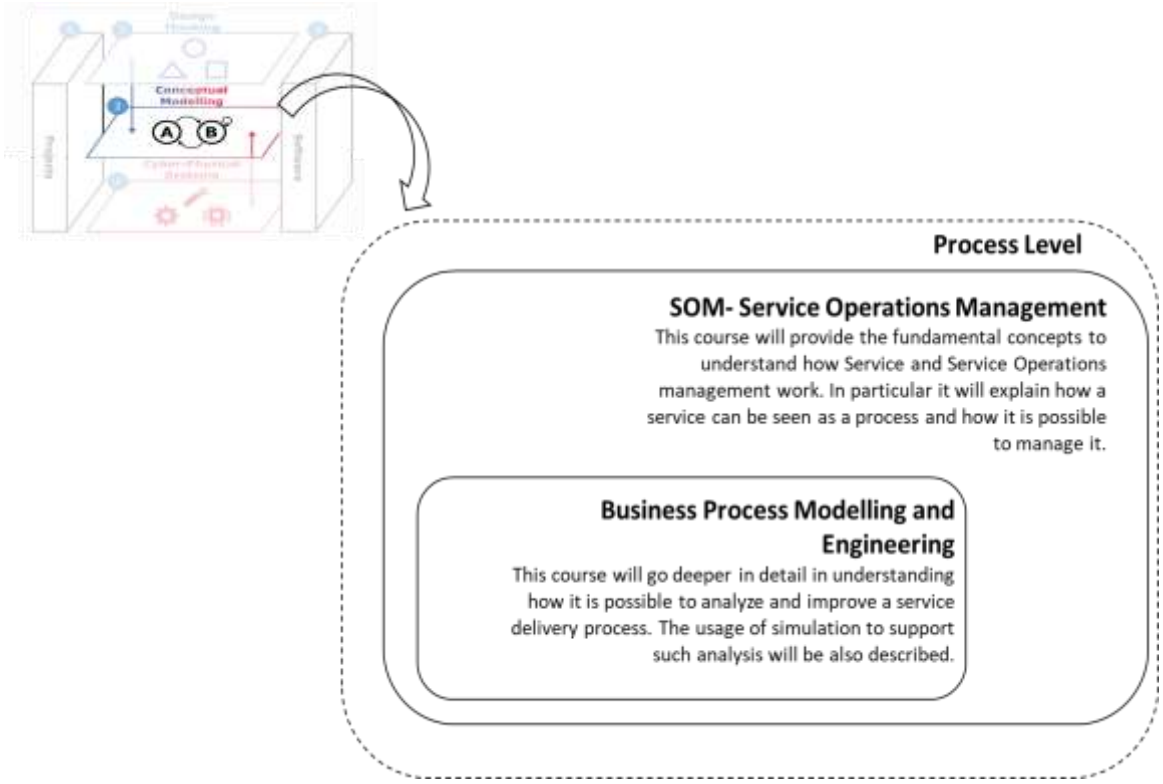


*Figure 5 Training courses provided by UNIBG*

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 | • Case study<br>• Team working<br>• 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 | • Team working<br>• Practical case study<br>• Modelling exercise<br>• 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).

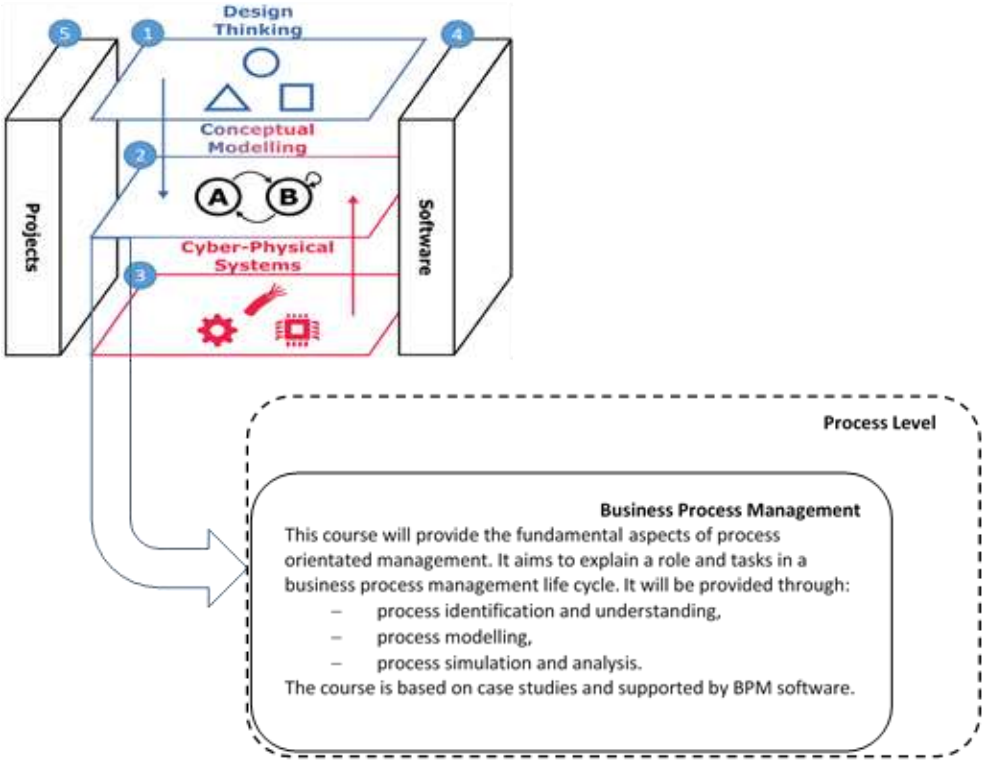


*Figure 6 Training courses provided by UNIBIAL*

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<br>Stage 2 – Rules of BPM<br>Stage 3 – "As-is" process analysis and modelling<br>Stage 4 – "To-be" process analysis and designing<br>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<br>Be capable of implementing some hands-on tools (adopting Bee-up) to design the models<br>Get the basic ideas how robots cooperate in the real settings<br>Cultivate more sense of robotics |
| Method | Modelling practice<br>case study |
| Target groups | Vocational training: professionals on automation<br>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<br>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 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 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) |
| |

**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 | | | | | |