



Report WP3: A3

Core textbook content preparation: Preparation of core textbook content



Result

Preparation of core textbook content

Related to

WP3-A3: Preparation of core textbook content

Statement of originality

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1. Introduction

WP3 is divided into 4 main Activities (A1-A4). This report comprises the information associated with the work done for the third activity A3, namely “**WP3-A3: Preparation of core textbook content**”. The University of Pisa (UNIPi) is the leading organization and coordinator for this work package.

The results of this activity are the templates defined during A2 filled with the material from each member of the consortium.

The following Table 1 summarizes the main acronyms in alphabetic order, full name and short description.

Table 1: Acronyms, full name, and short descriptions

Acronym	Full name	Short description
ATs	Assessment Tasks	In the Constructive Alignment framework, assessment tasks are not isolated evaluations but are purposefully linked to the specified Intended Learning Outcomes (ILOs). They serve as a means to verify whether students have successfully achieved the learning objectives set forth in the curriculum.
CA	Constructive Alignment	Constructive Alignment (CA) is a pedagogical theory and framework developed by John Biggs that emphasizes the importance of alignment in the design and delivery of educational experiences. The key components of constructive alignment include Intended Learning Outcomes (ILOs), Teaching and Learning Activities (TLA), and Assessment Tasks (ATs). The theory posits that for effective learning to occur, these three components must be closely aligned to ensure coherence and transparency in the educational process.
CONALI	Constructive Alignment Ontology	The CONstructiveALignment (CONALI) ontology, is a recent application of ontologies in education, specifically in the context of Constructive Alignment (CA). Developed using the Ontology Web Language (OWL), CONALI provides a framework to represent the body of knowledge related to CA, encompassing semantic relationships in a computer-readable format. The last version is CONALI 2.0.

EdU	Educational Units	Low level granularity distinct modules or components within an educational program or curriculum. These units are designed to cover specific topics, themes, or skills, and they serve as the building blocks of the overall educational experience.
EGV	Educational Goal Verb	An Educational Goal Verb refers to a verb that articulates the specific actions or behaviors that students are expected to demonstrate as part of achieving educational goals. By incorporating precise verbs into ILOs, educators can better communicate the intended depth and complexity of learning, facilitating the alignment between ILOs, Teaching and Learning Activities (TLA), and Assessment Tasks (ATs) as per the principles of constructive alignment.
HE	Higher Education	Education that takes place at universities, colleges, and other institutions that award academic degrees. It typically follows the completion of secondary education (high school) and offers more advanced and specialized instruction. Higher education includes undergraduate and postgraduate programs, leading to degrees such as associate's, bachelor's, master's, and doctoral degrees.
ILOs	Intended Learning Outcomes	These are clear, specific, and measurable statements that articulate what students are expected to know, understand, and be able to do by the end of a course or educational program. ILOs serve as the starting point for instructional design and guide the selection of teaching strategies and assessment methods. These are made by EGV, context and content.
OWL	Ontology Web Language	Web Ontology Language is a powerful and expressive language used for representing and sharing ontologies on the World Wide Web. An ontology is a formal representation of knowledge, typically describing the relationships between entities within a specific domain. OWL is particularly designed to support the development of ontologies that enable machines to reason about information and enhance interoperability between applications.
SOLO	Structure of Observed Learning Outcome	The Structure of Observed Learning Outcome (SOLO) taxonomy is an educational framework designed to assess the levels of understanding and learning outcomes in students. SOLO taxonomy categorizes learning outcomes into different levels of complexity, providing a way to measure the depth of understanding a student has reached.

TLA	Teaching and Learning Activities	Methods, strategies, and activities employed by educators to facilitate student learning. In constructive alignment, TLAs are carefully chosen and designed to directly support the achievement of the intended learning outcomes, according to the selected EGV. The aim is to create engaging and relevant learning experiences that guide students toward the desired understanding and skills.
TET	The Evolving Textbook	Current project: development of a platform for engineering EdU representation, focusing on CA. The platform of TET requires to be built on educational ontology presenting scalability, and with alignment in content to allow collaborative update of the material.

2. WP3-A3: Preparation of core textbook content

2.1. Results

During this activity the partner involved in the project collected EdU information following the template developed in accordance to the CONALI 3.0 (WP3-A2). Such templates were developed and filled by each institution (i.e. UNIPi, UNILJ, PRZ, KTH). Four EdUs were initially planned: 1. Mechatronics (UNILJ), 2. Assembly (KTH), 3. Production planning and monitoring (UNIPi), 4. Simulations (PRZ). Finally, the consortium decided to create six EdUs. The generated material is reported as follows (with a link to the online version provided)

1. I) Mechatronic Actuators, Partner: UNILJ¹ (Appendix)
2. I) Assembly technology; II) Planning and control, Partner: KTH² (Appendix)
3. I) Manufacturing processes, Partner: UNIPi³ (Appendix)
4. I) Data analysis; II) Simulation modelling, Partner: PRZ⁴ (Appendix)

¹ <https://unilj.sharepoint.com/:f:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A3%20Preparation%20of%20core%20textbook%20content/UNILJ?csf=1&web=1&e=SDouMK>

² <https://unilj.sharepoint.com/:f:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A3%20Preparation%20of%20core%20textbook%20content/KTH?csf=1&web=1&e=LTVC GG>

³ <https://unilj.sharepoint.com/:f:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A3%20Preparation%20of%20core%20textbook%20content/UNIPi?csf=1&web=1&e=QOygrT>

⁴ <https://unilj.sharepoint.com/:f:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A3%20Preparation%20of%20core%20textbook%20content/PRZ?csf=1&web=1&e=kl4rN3>

Appendix

2.2. UNILJ

Intended Learning Outcomes (ILOs)

The template for the formulation of the ILO is emphasizing the student perspective. All the ILO are formulated to address directly what is expected from the learner after following the related educational unit. Three are the key elements:

- **Short description:** ILOs has in general from 150 to 250 characters.
- **Bloom Verb Level:** detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy¹ selecting one of the following level:
 - o Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
 - o Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
 - o Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
 - o Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
 - o Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
 - o Level 6_Produce new or original work "Create": (design, assemble, construct, conjecture, formulate, author, investigate)
- **Content** to which the action indicated by the verb refer to and keywords enclosed in parentheses and in italics
- **Context** where the action for the related content must be applied and keywords enclosed in parentheses and in italics

Table 1: ILOs for the Course: Mechatronic Actuators, Partner: UNILJ

	Short description	Bloom Verb level	Content (<i>keywords</i>)	Context (<i>keywords</i>)
ILO1	Compare pneumatic, hydraulic and electric actuators and select a suitable actuator for a particular application in terms of cost, environmental conditions and operating conditions.	Level 4: analyse, compare Level 5: evaluate, select	pneumatic actuators, hydraulic actuators, electric actuators, characteristics, actuators cost, environmental conditions, operating conditions <i>(actuators, characteristics, comparison)</i>	selection of a suitable actuator for a particular application <i>(mechatronic application, suitable actuator, costs, environmental conditions, operating conditions)</i>
ILO2	Understand the role of different electronic semiconductor elements for mechatronic actuators and implement them.	Level 2: understand Level 3: apply, implement	semiconductor elements for mechatronic actuators, diodes, transistors, thyristors, silicon controlled rectifiers, insulated-gate bipolar transistor, characteristics	use of semiconductor elements in mechatronic actuator applications <i>(signal processing, control and regulation, power management, sensing and feedback, heat dissipation, protection)</i>

¹ For more info refer to: <https://doi.org/10.3390/educsci12070438>.

			<i>(semiconductor, semiconductor elements, diode, transistor, thyristor)</i>	
ILO3	Implement drive solutions with different electric drives on different platforms.	Level 3: apply, implement	mechanical drives, equations of motion, linear systems, motion trajectories, velocity profiles, axis types, bearing types, coupling types, sensors, torque matching <i>(drives, linear systems, motion, displacement, velocity, acceleration, velocity profile, displacement, precision and accuracy, axes, bearings, couplings)</i>	implementation of drives for mechatronic applications on different platforms <i>(mechatronic application, drive solutions, development platforms)</i>
ILO4	Use a mechatronic actuator in a closed-loop system.	Level 3: apply, use	actuator as part of a control system, modelling of control systems, sensors, open and closed-loop control and regulation, implementation of controllers, PID control <i>(control system, modelling, open-loop control, closed-loop control and regulation, controller, PID control)</i>	mechatronic actuator used in a closed-loop system for precise and stable control according to specified requirements for the time behaviour of a system <i>(actuator precise and stable control, operating requirements, time behaviour)</i>

Teaching and Learning Activities (TLA)

The template for the formulation of the TLA is emphasizing the following dimensions:

- What is the teacher supposed to do to enact the underlying ILO
- What is the learner supposed to do to enact the underlying ILO
- How does the suggested activity relate to good teaching practices as expressed in the 7 principles of good learning²

Table 2.1: TLAs for the Course: Mechatronic Actuators, Partner: UNILJ

TODO: TOLE TABELO REVIDIRAJ, POTEM KO IZPOLNIŠ ŠE TABELO 2.2. – DEJANSKI TEACHING ASSIGNMENTI

ILO reference (Highlight the Verb that need be aligned)	Teaching Activity (What the teachers do)	Learning Activity (What the students do)	How does this use the 7 Principles of good learning
ILO1 Compare pneumatic, hydraulic and electric actuators and select a suitable actuator for a particular application in terms of cost, environmental conditions and operating conditions	TA 1.1 Present different types of actuators TA 1.2 Explain the advantages and disadvantages of different types of actuators in real applications in terms of cost, environmental and operating conditions. TA 1.3 Describe and demonstrate real-world applications of selected types of actuators with a focus on electric actuators (motors). TA 1.4 Encourage discussion on the correct choice of actuator type	LA 1.1 Listen to the presentation, take notes, and ask questions. LA 1.2 Listen to the presentation, take notes, and ask questions. LA 1.3 Apply and evaluate the use of selected types of electric actuators in a laboratory environment: DC motor, stepper motor, servo motor, asynchronous motor. Students work in small groups. LA 1.4 Discuss the experience of testing actuators in	Encourages contact between students and faculty LA 1.1 LA 1.2 TA 1.4 LA 1.4 Develops cooperation among students LA 1.3 Encourages active learning TA 1.3 TA 1.4 LA 1.3 LA 1.4 Gives prompt feedback TA 1.3 TA 1.4 LA 1.3 LA 1.4 Emphasizes time on task LA 1.3 LA 1.4 Respects diverse talents and ways of

² 7 principles of good learning:

- encourages contact between students and faculty,
- develops reciprocity and cooperation among students,
- encourages active learning,
- gives prompt feedback,
- emphasizes time on task,
- communicates high expectations
- respects diverse talents and ways of learning

Arthur W. Chickering and Zelda F. Gamson (1987)

	depending on the application.	the laboratory and discuss the selection of actuators.	learning LA 1.3 LA 1.4
ILO2 Understand the role of different electronic semiconductor elements for mechatronic actuators and implement them.	TA 2.1 Present semiconductor elements. TA 2.2 Explain and show where and how are semiconductor elements used for mechatronic applications. TA 2.3. Describe a real application of semiconductor elements usage for processing signals.	LA 2.1 Listen to the presentation, take notes, and ask questions. LA 2.2 Listen to the presentation, take notes and ask questions. LA 2.3 Apply semiconductor elements for processing signals (rectifying), for generating control signals, for amplifying and switch operations, and to tackle common issues.	Encourages contact between students and faculty LA 2.1 LA 2.2 Develops cooperation among students LA 2.3 Encourages active learning TA 2.3 LA 2.3 Gives prompt feedback TA 1.3 LA 1.3 Emphasizes time on task LA 2.3 Respects diverse talents and ways of learning LA 2.3
ILO3 Implement drive solutions with different electric drives on different platforms.	TA 3.1 Present types of drives for mechatronic actuators: linear drives, drives with wheels, force-based drives. TA 3.2 Present mechanical components of drives: guides, axes, bearings, couplings, sensors. TA 3.3 Explain and show mathematical models of drive systems: equations of motion (displacement, velocity, acceleration), friction. TA 3.4 Explain and show properties of drives: motion trajectory, absolute and relative displacement, velocity profiles, precision and accuracy, torque matching.	LA 3.1 Listen to the presentation, take notes, and ask questions. Evaluate a variable frequency drive (VFD) for control of an asynchronous electric motor). Students work in small groups. LA 3.2 Listen to the presentation, take notes, and ask questions. LA 3.3 Listen to the presentation, take notes, and ask questions. LA 3.4 Apply and evaluate measurements of actuator displacement, velocity and acceleration. Apply and evaluate different	Encourages contact between students and faculty LA 3.1 LA 3.2 LA 3.3 TA 3.5 LA 3.5 Develops cooperation among students LA 3.1 LA 3.4 Encourages active learning LA 3.1 TA 3.3 TA 3.4 LA 3.4 Gives prompt feedback LA 3.1 TA 3.3 TA 3.4 LA 3.4 TA 3.5 LA 3.5 Emphasizes time on task LA 3.1 LA 3.4

	TA 3.5 Encourage discussion on drive solutions for different applications and development platforms.	velocity profiles. Students work in small groups. LA 3.5 Discuss the experience of testing drives in the laboratory and evaluate its properties.	Respects diverse talents and ways of learning LA 3.1 LA 3.4 LA 3.5
ILO 4 Use a mechatronic actuator in a closed-loop system.	TA 4.1 Present the basics of linear control theory. TA 4.2 Describe and show the types of control (open-loop, closed-loop). TA 4.3 Describe and show the types of measurements needed for closed-loop control: potentiometer, resolver, encoder, tacho-generator. TA 4.4 Explain and show the control algorithms with emphasis on PID control. TA 4.5 Describe and show the implementation of control algorithms in practical applications: PIC microcontroller, Arduino microcontroller, Raspberry Pi micro computer	LA 4.1 Listen to the presentation, take notes, and ask questions. LA 4.2 Listen to the description, take notes, and ask questions. LA 4.3 Apply and evaluate resolver, potentiometer, incremental and absolute encoder, and tacho-generator for measurement of displacement and velocity. Students work in small groups. LA 4.4 Listen to the presentation, take notes, and ask questions. LA 4.5 Apply and evaluate control algorithm on Arduino microcontroller using Arduino IDE and C++ programming language. Students work in small groups.	Encourages contact between students and faculty LA 4.1 LA 4.2 Develops cooperation among students LA 4.3 LA 4.5 Encourages active learning TA 4.2 TA 4.3 TA 4.4 TA 4.5 LA 4.3 LA 4.5 Gives prompt feedback LA 4.3 LA 4.5 Emphasizes time on task LA 4.3 LA 4.5 Respects diverse talents and ways of learning LA 4.3 LA 4.5

Table 2.2: TAs for the Course: Mechatronic Actuators, Partner: UNILJ

Course moment ³	Weekday, date and time slot ⁴	LA Type ⁵	Location ⁶	ILO Code	TLA Code ⁷	Course material ⁸	Keywords	Link to the material
Class	Friday, 2 hours	Lecture	Presence	ILO 1	TA 1.1 LA 1.1	Slides	Introduction History of actuators Types of actuators Actuators as part of control systems	SLIDES
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 1	TA 1.1 TA 1.2 LA 1.1 LA 1.2	Slides	Types of actuators Pneumatic actuators Hydraulic actuators Advantages and disadvantages Applications of actuators Electrical and mechanical components for actuators	SLIDES
Class	Friday, 2 hours	Lecture	Presence	ILO 1	TA 1.1 LA 1.1	Slides	Electrostatics Electromagnetism Electric motors Typical signals Properties of electrical signals (DC and AC)	SLIDES
Class	Friday, 2 hours	Problem-solving tasks, Debates, Brainstorm	Presence	ILO 1	TA 1.1 LA 1.1	Video lecture, slides	Electrostatics and electromagnetism Solving DC circuits Use superposition for linear problems Loop current method Electrical signals and properties, PWM Using Matlab to solve circuit equations	SLIDES VIDEO
Laboratory	4 groups, 2 hours	Laboratory, Group work, Discussion	Presence, home	ILO 1	TA 1.3 LA 1.3	E-classroom laboratory setup description and exercise instructions, report submission	Generating electrical signals with a microcontroller Arduino Due microcontroller Arduino IDE and C++ Step signal Square signal Saw signal Trapezoidal signal PWM signal Sine signal Oscilloscope for the graphical display of signals	LINK
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 2	TA 2.1 TA 2.2 TA 2.3 LA 2.1 LA 2.2	Slides	Semiconductor elements for mechatronic actuators Diodes Bipolar transistors Unipolar transistors Thyristors Silicon controlled rectifier	SLIDES

³ Can be physical meeting or homework or any other kind of activity that need to be done in the course (e.g., visit). It shows the chronological flow of the course.

⁴ It helps understanding relative positioning and duration of different course moments.

⁵ referring to column 3 of the Table 3 (can be one of the listed examples). For more info refer to <https://doi.org/10.3390/educsci12070438>.

⁶ Class, home, lab, company

⁷ Follow the code of the previous template Table 2.1 (TA)

⁸ Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

							Insulated-gate bipolar transistors	
Class	Friday, 2 hours	Problem-solving tasks, Debates, Brainstorm	Presence	ILO 2	TA 2.1 TA 2.2 TA 2.3 LA 2.1 LA 2.2 LA 2.3	Video lecture, slides	Use of a diode to rectify an AC signal Design of a suitable rectifier circuit for AC voltage Use of a bipolar transistor to control a DC motor Use of an H-bridge with MOSFET transistor for bidirectional control of a DC motor Silicon controlled rectifier (SCR) and its use to compensate for the change in motor torque with changes in magnetic field Insulated gate bipolar transistor used as a switch in power applications	SLIDES VIDEO
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 TA 1.4 LA 1.1 LA 1.2	Slides	DC electric motor Construction of a direct current motor Principles of operation Mathematical models Properties of an electrical direct current signal Block diagram of a DC motor Separately excited DC motor Parallel (shunt-excited) DC motor Series-excited (self-excited) DC motor Hybrid DC motor	SLIDES
Class	Friday, 2 hours	Problem-solving tasks, Debates, Brainstorm	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 TA 1.4 LA 1.1 LA 1.2	Video lecture, slides	Direct current electric motor Basic properties and equations Brushless DC motor Separately excited DC motor Parallel (shunt-excited) DC motor Series-excited (self-excited) DC motor Hybrid DC motor	SLIDES VIDEO
Laboratory	4 groups, 2 hours	Laboratory, Group work, Discussion	Presence, home	ILO 1	TA 1.2 TA 1.3 TA 1.4 LA 1.3 LA 1.4 LA 3.4 LA 4.3	E-classroom laboratory setup description and exercise instructions, report submission	DC electric motor Electrical wiring Generation of a PWM signal for controlling a DC motor Tachometer for measuring the motor speed Arduino Due microcontroller Arduino IDE and C++ Measuring the speed via PWM characteristics Setting the PWM signal for a specific motor speed Application of the motor brake	LINK
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 LA 1.1 LA 1.2	Slides	H-bridge with MOSFET transistors for controlling DC motors	SLIDES

							Pulse width modulated signal for controlling a DC motor DC motor as part of a control system Determining the parameters of DC motor control systems using impulse transfer function PIC and Arduino microcontrollers for DC motors	
Laboratory	4 groups, 2 hours	Laboratory, Group work, Discussion	Presence, home	ILO 1	TA 1.2 TA 1.3 TA 1.4 LA 1.3 LA 1.4 LA 3.4	E-classroom laboratory setup description and exercise instructions, report submission	Servo motor system Robot arm HiWonder Jetmax Servo motor data sheet analysis: type, motors, control, characteristics Control of servo motors via a web-based graphical user interface NodeMCU ESP32 development board Arduino IDE and C++ Remote (programmable) servo motor control for robot arm displacements Basic robot arm displacements Advanced robot arm displacements (object movement)	LINK
Class	Friday, 2 hours	Lecture	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 LA 1.1 LA 1.2	Slides	Modelling of electrical AC signals Representation of AC signals using phasors Generalisation of resistance and conductance – impedance and admittance 3-phase AC electric sources and motors	SLIDES
Class	Friday, 2 hours	Problem-solving tasks, Debates, Brainstorm	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 TA 1.4 LA 1.1 LA 1.2	Video lecture, slides	AC electric signals and properties RLC circuits Impedance and admittance Solving AC circuits Power in AC circuits Power factor correction 3-phase AC generator 3-phase AC motor Delta or star circuits	SLIDES VIDEO
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 TA 1.4 LA 1.1 LA 1.2	Slides	Asynchronous motor Principles of operation Squirrel cage asynchronous motor Asynchronous motor with wound rotor Properties of the asynchronous motor Mathematical model and linearisation Types of asynchronous motor control Variable frequency drive Synchronous AC motors	SLIDES
Class	Friday, 2 hours	Problem-solving tasks, Debates, Brainstorm	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 TA 1.4 LA 1.1	Video lecture, slides	Synchronous motor Characteristics of the synchronous motor: torque, synchronous reactance, power	SLIDES VIDEO

					LA 1.2		Synchronous motor with variable frequency drive (VFD) Induction motor Characteristics of the induction motor: rotor speed, full load torque, slip Induction motor with direct-on-line drive (DOL) Induction Asynchronous motor with wound rotor Squirrel cage asynchronous motor Double squirrel cage asynchronous motor	
Laboratory	4 groups, 2 hours	Laboratory, Group work, Discussion	Presence, home	ILO 1	TA 1.2 TA 1.3 TA 1.4 TA 3.4 LA 1.3 LA 1.4 LA 3.1 LA 3.4	E-classroom laboratory setup description and exercise instructions, report submission	Asynchronous motor Data sheet analysis: type, principle of operation, dynamic properties, stability Variable frequency drive (VFD) Analysing the data sheet and user manual: operating principles, manual control Integrated manual control of the VFD Setting the asynchronous speed by adjusting the VFD frequency Analysing and applying the motor velocity profile	LINK
Laboratory	4 groups, 2 hours	Laboratory, Group work, Discussion	Presence, home	ILO 1	TA 1.2 TA 1.3 TA 1.4 LA 1.3 LA 1.4 LA 3.4	E-classroom laboratory setup description and exercise instructions, report submission	Asynchronous motor Variable frequency drive (VFD) Programmable motor control with the CX-Drive software Basic control algorithm (on/off control) Setting the motor speed Setting the motor velocity profile Setting the torque characteristic (V/f curve)	LINK
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 TA 1.4 LA 1.1 LA 1.2	Slides	Stepper motors Principles of operation Construction of stepper motors Types of stepper motors Bipolar stepper motors Unipolar stepper motors Hybrid stepper motors Stepper motor control Properties of stepper motors Microstepping Brushless DC motor (BLDC)	SLIDES
Class	Friday, 2 hours	Problem-solving tasks, Debates, Brainstorm	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 TA 1.4 LA 1.1 LA 1.2	Video lecture, slides	Stepper motors Bipolar stepper motors Unipolar stepper motors Microstepping Stepper motor with linear guides	SLIDES VIDEO
Laboratory	4 groups, 2 hours	Laboratory, Group work, Discussion	Presence, home	ILO 1	TA 1.2 TA 1.3 TA 1.4 LA 1.3	E-classroom laboratory setup description	DC stepper motors Analysing the data sheet: type, properties, dynamic characteristics	LINK

					LA 1.4 LA 3.4	and exercise instructions, report submission	AdaFruit MotorShield shield for the control of stepper motors Arduino Due microcontroller Arduino IDE and C++ Stepper motor operating modes: single, double, interleave and microstep operation Microstep: full step, 1/8 microstep, 1/16 microstep	
Class	Friday, 2 hours	Lecture	Presence	ILO 3	TA 3.1 TA 3.3 TA 3.4 TA 3.5 LA 3.1 LA 3.3	Slides	Mechanical drives Theoretical basics Equation of motion: moment of inertia, load moment, acceleration, transmission ratio Motion trajectories Velocity profiles	SLIDES
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 3	TA 3.1 TA 3.2 TA 3.3 TA 3.5 LA 3.1 LA 3.2	Slides	Mechanical drives Linear systems Linear guides Systems with wheels Force-based systems Absolute and relative displacement Precision and accuracy Components of drives: axes, bearings, couplings, sensors Torque matching	SLIDES
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 4	TA 4.1 TA 4.2 TA 4.3 TA 4.5 LA 4.1 LA 4.2	Slides	Mechatronic actuator in a closed-loop system Open-loop system Closed loop system Sensors: resolver, potentiometer, encoder, tachogenerator Types of electric motors control	SLIDES
Class	Friday, 2 hours	Problem- solving tasks, Debates, Brainstorm	Presence	ILO 4	TA 4.1 TA 4.3 LA 4.1 LA 4.3	Video lecture, slides	Methods for measuring the displacement, velocity and acceleration of mechatronic actuators Resolver Rotary potentiometer Absolute encoder Incremental encoder	SLIDES VIDEO
Laboratory	4 groups, 2 hours	Laboratory, Group work, Discussion	Presence, home	ILO 4	TA 4.1 TA 4.3 TA 4.5 LA 4.1 LA 4.3 LA 4.5	E-classroom laboratory setup description and exercise instructions, report submission	Absolute rotary encoder Incremental rotary encoder Arduino Due microcontroller Arduino IDE Arduino C++ programming languages Electrical wiring Programmes for reading the encoder output Programmes for converting the encoder outputs into rotation angle and rotation speed	LINK
Class	Friday, 2 hours	Lecture, Discussion	Presence	ILO 4	TA 4.2 TA 4.4 TA 4.5 LA 4.2 LA 4.4	Slides	Types of controllers for electric motors Microcontroller Microcomputer Industrial computer PLC Control algorithms	SLIDES

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Class	Friday, 2 hours	Lecture	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3 TA 1.4 LA 1.1 LA 1.2	Slides	PID control Alternative drives for mechatronic actuators Piezoelectric materials Piezoelectric motors Shape memory-based alloy actuators Solenoids	SLIDES
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Table 3: Learning activities examples (column 3)

Bloom Taxonomy	EGV	Learning Activities (Examples)
Remember	arrange, define, list, identify	Lecture, Reading materials
Comprehension	classify, discuss, present, rewrite	Mind map, Think-pair-share, Discussion, Reflection, Fishbowl
Apply	solve, calculate, demonstrate, organize, use	Case study in real-life situation, Problem-solving tasks, Roleplay, Group work, Laboratory
Analyze	categorize, contrast, compare, debate, inspect	Debates, Class discussion, Jigsaw method, Think-pair-share, Fishbowl, Laboratory
Evaluate	assess, conclude, justify, measure	Journal, Debates, Mind map, Peer evaluation
Create	design, develop, revise, formulate	Brainstorm, Design a presentation, Create a new report, Construct a roleplay

Assessment Task

The template for the formulation of the AT is emphasizing different assessment strategies for different verbs and different learning style.

Table 4: TAs for the Course: Mechatronic Actuators, Partner: UNILJ

ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO1 Compare pneumatic, hydraulic and electric actuators and select a suitable actuator for a particular application in terms of cost, environmental conditions and operating conditions	Bloom level: 5 Type***: group work Short description: Write a report on laboratory exercises on different types of actuators. The report includes measurements, answers to the questions, evaluations and discussions.	Bloom level: 6 Type***: Project Short description: Design and build a mechatronic system that contains a selected actuator.	
ILO2 Understand the role of different electronic semiconductor elements for mechatronic actuators and implement them.	Bloom level: 5 Type***: group work Short description: Write a report on laboratory exercises on different types of semiconductor components. The report includes measurements, answers to the questions, evaluations and discussions.	Bloom level: 6 Type***: Project Short description: Design and build a mechatronic system that uses semiconductor components for various functionalities.	
ILO3 Implement drive solutions with different electric drives on different platforms.	Bloom level: 5 Type***: group work Short description: Write a report on laboratory exercises on different types of electric motor drives. The report includes measurements, answers to the questions, evaluations and discussions.		
ILO4 Use a mechatronic actuator in a closed-loop system.	Bloom level: 5 Type***: group work Short description: Write a report on laboratory exercises on different types of electric motor closed-loop control. The report includes measurements, answers to	Bloom level: 6 Type***: Project Short description: Design and build a mechatronic system that functions as a closed-loop system.	

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	the questions, evaluations and discussions.		
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Table 5: AT examples

Bloom Taxonomy	EGV	Assessment Task (Examples)
Remember	arrange, define, list, identify	Multiple choice, quiz/test, question banks, take-home examinations
Comprehension	classify, discuss, present, rewrite	Concept/mind maps, interview, debate, problem sheet, minutes, forum posts, open-book, individual presentation, group presentation, viva-voce
Apply	solve, calculate, demonstrate, organize, use	Abstract, case study, problem-solving tasks, roleplay, group work, portfolio, workbook, project
Analyze	categorize, contrast, compare, debate, inspect	Thesis, annotated bibliography, literature review, debates, class discussion, jigsaw method, think-pair-share, fishbowl, laboratory
Evaluate	assess, conclude, justify, measure	Report, reflection, journal, debates, mind map, peer evaluation, group work, teamwork
Create	design, develop, revise, formulate	Project, thesis, article, essay, creative work, demonstration, performance, roleplay, recorded/rendered creative work,

2.3. KTH

Intended Learning Outcomes (ILOs)

The template for the formulation of the ILO is emphasizing the student perspective. All the ILO are formulated to address directly what is expected from the learner after following the related educational unit. Three are the key elements:

- **Short description:** ILOs has in general from 150 to 250 characters.
- **Bloom Verb Level:** detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy¹ selecting one of the following level:
 - o Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
 - o Level2_ Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
 - o Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
 - o Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
 - o Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
 - o Level 6_Produce new or original work "Create": (design, assemble, construct, conjecture, formulate, author, investigate)
- **Content** to which the action indicated by the verb refer to and keywords enclosed in parentheses and in italics
- **Context** where the action for the related content must be applied and keywords enclosed in parentheses and in italics

Table 1: ILOs for the Course Assembly technology, Partner: KTH

	Short description	Bloom Verb level	Content (<i>keywords</i>)	Context (<i>keywords</i>)
ILO1	describe the role of the assembly process within the manufacturing domain and discuss its importance	Level_2	the role of the assembly process, importance (<i>assembly process, assembly line</i>)	Manufacturing domain
ILO2	create mathematical and feature models of assemblies and use them in context of design and evaluation of assembly systems	Level_6	mathematical and feature models of assemblies (<i>modelling, assembly feature, parameters, constraints, tolerances</i>)	design and evaluation of assembly systems (<i>design, assembly system</i>)
ILO3	account for the dynamic and static constraints of a manual or automatic assembly process	Level_4	the dynamic and static constraints (<i>constraints, dynamic, static</i>)	a manual or automatic assembly process (<i>assembly process, manual assembly, automatic assembly</i>)

¹ For more info refer to: <https://doi.org/10.3390/educsci12070438>.

ILO4	analyse a given product and define feasible assembly sequences	Level_4	Feasible assembly sequences <i>(assembly sequences, product analysis, workflow analysis)</i>	Given product
ILO5	choose the best sequence by applying technical and economic criteria	Level_4	Best sequence applying technical and economic criteria <i>(sequence analysis, technical criteria, economic criteria)</i>	Given product
ILO6	describe the function of all the elements of an assembly system (both automatic and manual)	Level_2	the function of all the elements <i>(function, element)</i>	an assembly system (both automatic and manual) <i>(assembly system, manual assembly, automatic assembly)</i>
ILO7	evaluate the impact of the product design on the assembly process, by applying the Boothroyd DFA methodologies	Level_5	the impact of the product design by applying the Boothroyd DFA methodologies <i>(DFA, product design, impact, design efficiency)</i>	on the assembly process <i>(assembly process)</i>
ILO8	identify the requirements on design of an assembly station and provide instructions for the subsequent implementation	Level_2	Requirements on design and instructions for the subsequent implementation <i>(Assembly sequence, assembly requirements, design requirement)</i>	Assembly station <i>(assembly station)</i>
ILO9	calculate the costs and the most important economical key performance indicators (KPIs) for standard assembly systems (both manual and automatic)	Level_3	the costs and the most important economical key performance indicators (KPIs) <i>(KPI, cost, economic performance)</i>	standard assembly systems (both manual and automatic) <i>(standard assembly system, manual assembly, automatic assembly)</i>

Teaching and Learning Activities (TLA)

The template for the formulation of the TLA is emphasizing the following dimensions:

- What is the teacher supposed to do to enact the underlying ILO
- What is the learner supposed to do to enact the underlying ILO
- How does the suggested activity relate to good teaching practices as expressed in the 7 principles of good learning²

Table 2.1: TLAs for the Course: Assembly technology, Partner: KTH

ILO reference (Highlight the Verb that need be aligned)	Teaching Activity (What the teachers do)	Learning Activity (What the students do)	How does this use the 7 Principles of good learning
ILO1 describe the role of the assembly process within the manufacturing domain and discuss its importance	TA 1.1 Present the role of assembly process in manufacturing. TA1.2 Explain why assembly process are important.	LA 1.1 Listen to the presentation, take notes, and ask questions. LA 1.2 Listen to the presentation, take notes and ask questions. LA 1.3 Discuss the importance of assembly process.	Encourages contact between students and faculty, LA 1.1 LA1.2 Gives prompt feedback, LA 1.3
ILO2 create mathematical and feature models of assemblies and use them in context of design and evaluation of assembly systems	TA2.1 Explain mathematical and feature models of assemblies in the context of design and evaluation of assembly systems. TA2.2 Describe and show instructions for the project	LA 2.1 Listen to the presentation, take notes, and ask questions. LA 2.2 Apply and evaluate appropriate models.	Encourages contact between students and faculty LA 2.1 LA 2.2 Encourages active learning LA 2.2 Gives prompt feedback, LA 2.2 Respects diverse talents and ways of learning

² 7 principles of good learning:

- encourages contact between students and faculty,
- develops reciprocity and cooperation among students,
- encourages active learning,
- gives prompt feedback,
- emphasizes time on task,
- communicates high expectations
- respects diverse talents and ways of learning

Arthur W. Chickering and Zelda F. Gamson (1987)

			TA 2.2 LA 2.2
ILO3 account for the dynamic and static constraints of a manual or automatic assembly process	TA3.1 Explain dynamic and static constraints of assembly process TA3.2 Describe and show instructions for the project	LA 3.1 Listen to the presentation, take notes, and ask questions. LA 3.2 Evaluate the constraints of assembly process.	Encourages contact between students and faculty LA 3.1 LA 3.2 Encourages active learning LA 3.2 Gives prompt feedback, LA 3.2 Respects diverse talents and ways of learning TA 3.2 LA 3.2
ILO4 analyse a given product and define feasible assembly sequences	TA 4.1 Explain assembly sequences. TA 4.2 Describe and show instructions for the project	LA 4.1 Listen to the presentation, take notes, and ask questions. LA 4.2 Evaluate and define feasible assembly sequence.	Encourages contact between students and faculty LA 4.1 LA 4.2 Encourages active learning LA 4.2 Gives prompt feedback, LA 4.2 Respects diverse talents and ways of learning TA 4.2 LA 4.2
ILO5 choose the best sequence by applying technical and economic criteria	TA 5.1 Explain technical and economic criteria for assembly sequences. TA 5.2 Describe and show instructions for the project	LA 5.1 Listen to the presentation, take notes, and ask questions. LA 5.2 Evaluate and choose the best assembly sequence using technical and economic criteria.	Encourages contact between students and faculty LA 5.1 LA 5.2 Encourages active learning LA 5.2 Gives prompt feedback, LA 4.2 Respects diverse talents and ways of learning TA 5.2 LA 5.2
ILO6 describe the function of all the elements of an assembly system (both automatic and manual)	TA 6.1 Present the function of elements of automatic and manual assembly system.	LA 6.1 Listen to the presentation, take notes, and ask questions.	Encourages contact between students and faculty, LA 6.1
ILO7	TA 7.1	LA 7.1	Encourages contact between students and faculty

evaluate the impact of the product design on the assembly process, by applying the Boothroyd DFA methodologies	Explain DFA methodologies. TA 7.2 Describe and show instructions for the project	Listen to the presentation, take notes, and ask questions. LA 7.2 Apply DFA methodologies to given product.	LA 7.1 LA 7.2 Encourages active learning LA 7.2 Gives prompt feedback, LA 7.2 Respects diverse talents and ways of learning TA 7.2 LA 7.2
ILO8 identify the requirements on design of an assembly station and provide instructions for the subsequent implementation	TA 8.1 Explain design requirements of assembly station. TA 8.2 Describe and show instructions for the project	LA 8.1 Listen to the presentation, take notes, and ask questions. LA 8.2 Discuss and explain the design requirements for assembly station implementation.	Encourages contact between students and faculty LA 8.1 LA 8.2 Encourages active learning LA 8.2 Gives prompt feedback, LA 8.2 Respects diverse talents and ways of learning TA 8.2 LA 8.2
ILO9 calculate the costs and the most important economical key performance indicators (KPIs) for standard assembly systems (both manual and automatic)	TA 9.1 Explain costs evaluation and economical KPIs for manual and automatic assembly systems. TA 9.2 Describe and show instructions for the project	LA 9.1 Listen to the presentation, take notes, and ask questions. LA 9.2 Use costs evaluation and KPIs for manual and automatic assembly.	Encourages contact between students and faculty LA 9.1 LA 9.2 Encourages active learning LA 9.2 Gives prompt feedback, LA 9.2 Respects diverse talents and ways of learning TA 9.2 LA 9.2

Table 2.2: TAs for the Course: Assembly technology, Partner: KTH

Course moment ³	Weekday, date and time slot ⁴	LA Type ⁵	Location ⁶	ILO Code	TLA Code ⁷	Course material ⁸	Keywords	Link to the material
Class	2 hours	Lecture	IRL	ILO1	TA1.1 TA1.2	slides	Introduction Industrial assembly Assembly model Key characteristic Assembly sequences and precedencies Assembly motions Cost evaluation Elements of system design	link
Class	2 hours	Lecture	IRL	ILO3 ILO6 ILO8	TA3.1 TA3.2 TA6.1 TA6.2 TA8.1 TA8.2	slides	Manual assembly Analysis of Single Model Assembly Lines Line Balancing Algorithms Mixed Model Assembly Lines Workstation Assembly Line Design Alternative Assembly Systems	link
Tutorial	2 hours	Tutorial	IRL	ILO4 ILO5	TA4.1 TA4.2 TA5.1 TA5.2	slides	Assembly sequences and precedencies	link
Tutorial	2 hours	Tutorial	IRL	ILO4	TA4.1 TA4.2	slides	Line balancing	link
Class	2 hours	Lecture	IRL	ILO3 ILO6	TA3.1 TA3.2 TA6.1 TA6.2	slides	Automatic assembly line High speed Qualitative analysis Assembly automation System configuration Feeder Partial automation Flexible automation	link
Class	2 hours	Lecture	IRL	ILO7	TA7.1 TA7.2	slides	DFA Degins for manual assembly Benefits Problems Design guidelines Design for automatic assembly	link
Tutorial	2 hours	Tutorial	IRL	ILO7	TA7.1 TA7.2	slides	DFA DFAA	Link Link Link
Class	2 hours	Lecture	IRL	ILO8	TA8.1 TA8.2	slides	Sensors Actuators Analog-to-digital conversion Digital-to-analog conversion Input/output devices Discrete data	Link
Class	2 hours	Lecture	IRL	ILO8	TA8.1 TA8.2	slides	Grasping process Grasping principles	link

³ Can be physical meeting or homework or any other kind of activity that need to be done in the course (e.g., visit). It shows the chronological flow of the course.

⁴ It helps understanding relative positioning and duration of different course moments.

⁵ referring to column 3 of the Table 3 (can be one of the listed examples). For more info refer to <https://doi.org/10.3390/educsci12070438>.

⁶ Class, home, lab, company

⁷ Follow the code of the previous template Table 2.1 (TA)

⁸ Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

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							Releasing principles Monitoring principles Hybrid grippers	
Class	2 hours	Lecture	IRL	ILO8	TA8.1 TA8.2	slides	Robot anatomy Robot attributes Robot control systems Robotics Sensors Industrial robots applications Robot programming Robot accuracy Robot repeatability	link
Tutorial	2 hours	Tutorial	IRL	ILO9	TA9.1 TA9.2	slides	Cost evaluation Manual assembly Automatic assembly	Link
Homework	25 hours (Throughout the course)	Create a new report Group work Problem-solving tasks	IRL Virtual Home	ILO2 ILO3 ILO4 ILO5 ILO7 ILO8 ILO9	TA2.1 TA2.2 TA3.1 TA3.2 TA4.1 TA4.2 TA5.1 TA5.2 TA7.1 TA7.2 TA8.1 TA8.2 TA9.1 TA9.2	-	Product description Bill of material Assembly feature Liaison diagram Precedence diagram Design for assembly Manual assembly Line balancing Workstation design Economic analysis Assembly systems	-

Table 3: Learning activities examples (column 3)

Bloom Taxonomy	EGV	Learning Activities (Examples)
Remember	arrange, define, list, identify	Lecture, Reading materials
Comprehension	classify, discuss, present, rewrite	Mind map, Think-pair-share, Discussion, Reflection, Fishbowl
Apply	solve, calculate, demonstrate, organize, use	Case study in real-life situation, Problem-solving tasks, Roleplay, Group work, Laboratory
Analyze	categorize, contrast, compare, debate, inspect	Debates, Class discussion, Jigsaw method, Think-pair-share, Fishbowl, Laboratory
Evaluate	assess, conclude, justify, measure	Journal, Debates, Mind map, Peer evaluation
Create	design, develop, revise, formulate	Brainstorm, Design a presentation, Create a new report, Construct a roleplay

Assessment Task

The template for the formulation of the AT is emphasizing different assessment strategies for different verbs and different learning style.

[Link](#) to material

Table 4: ATs for the Course: Assembly Technology, Partner: KTH

ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO1 describe the role of the assembly process within the manufacturing domain and discuss its importance	Bloom level: 2 Type***: Exam question Short description: Answer questions on the role of the assembly process within manufacturing domain.		
ILO2 create mathematical and feature models of assemblies and use them in context of design and evaluation of assembly systems	Bloom level: 6 Type***: Project Short description: Analyse the given product and develop mathematical and feature models of assemblies.		
ILO3 account for the dynamic and static constraints of a manual or automatic assembly process	Bloom level: 4 Type***: Exam question Short description: Answer questions on the presented dynamic and static constraints of manual or automatic assembly	Bloom level: 4 Type***: Project Short description: Analyse the given product and assess the dynamic and static constraints of manual production scenario.	
ILO4 analyse a given product and define feasible assembly sequences	Bloom level: 4 Type***: Project Short description: Analyse the given product and define its assembly sequence.		
ILO5	Bloom level: 4		

choose the best sequence by applying technical and economic criteria	Type***: Project Short description: Analyse the given product and define the best assembly sequence applying technical and economic criteria.		
ILO6 describe the function of all the elements of an assembly system (both automatic and manual)	Bloom level: 2 Type***: Exam question Short description: Answer questions on function of all elements in assembly system.		
ILO7 evaluate the impact of the product design on the assembly process, by applying the Boothroyd DFA methodologies	Bloom level: 5 Type***: Project Short description: Analyse the given product and assess its design applying the DFA method.		
ILO8 identify the requirements on design of an assembly station and provide instructions for the subsequent implementation	Bloom level: 2 Type***: Project Short description: Analyse the given product and define its requirements on design of an assembly station.		
ILO9 calculate the costs and the most important economical key performance indicators (KPIs) for standard assembly systems (both manual and automatic)	Bloom level: 3 Type***: ***: Project Short description: Analyse the given product and calculate its costs and KPIs.		

Table 5: AT examples

Bloom Taxonomy	EGV	Assessment Task (Examples)
Remember	arrange, define, list, identify	Multiple choice, quiz/test, question banks, take-home examinations
Comprehension	classify, discuss, present, rewrite	Concept/mind maps, interview, debate, problem sheet, minutes, forum posts, open-book, individual presentation, group presentation, viva-voce
Apply	solve, calculate, demonstrate, organize, use	Abstract, case study, problem-solving tasks, roleplay, group work, portfolio, workbook, project
Analyze	categorize, contrast, compare, debate, inspect	Thesis, annotated bibliography, literature review, debates, class discussion, jigsaw method, think-pair-share, fishbowl, laboratory
Evaluate	assess, conclude, justify, measure	Report, reflection, journal, debates, mind map, peer evaluation, group work, teamwork
Create	design, develop, revise, formulate	Project, thesis, article, essay, creative work, demonstration, performance, roleplay, recorded/rendered creative work,

Intended Learning Outcomes (ILOs)

The template for the formulation of the ILO is emphasizing the student perspective. All the ILO are formulated to address directly what is expected from the learner after following the related educational unit. Three are the key elements:

- **Short description:** ILOs has in general from 150 to 250 characters.
- **Bloom Verb Level:** detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy¹ selecting one of the following level:
 - o Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
 - o Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
 - o Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
 - o Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
 - o Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
 - o Level 6_Produce new or original work "Create": (design, assemble, construct, conjecture, formulate, author, investigate)
- **Content** to which the action indicated by the verb refer to and keywords enclosed in parentheses and in italics
- **Context** where the action for the related content must be applied and keywords enclosed in parentheses and in italics

Table 1: ILOs for the Course Planning and control, Partner: KTH

	Short description	Bloom Verb level	Content (keywords)	Context (keywords)
ILO1	explain fundamental principles used in traditional production planning and control systems	Level_2	fundamental principles <i>(production planning, production control, scheduling, inventory management, demand forecasting, capacity planning, production efficiency)</i>	in traditional production planning and control systems <i>(production planning, production control)</i>
ILO2	develop aggregate plans for manufacturing of a multi-component product	Level_6	aggregate plans <i>(aggregate planning, resource allocation, demand forecasting, cost optimization)</i>	manufacturing of a multi-component product <i>(multi-component product)</i>
ILO3	propose and motivate a Master Production Schedule and a Material Requirements Plan for a given aggregate plan	Level_3	Master Production Schedule and a Material Requirements Plan <i>(MRP, bill of material, enterprise resource planning, MPS)</i>	a given aggregate plan

¹ For more info refer to: <https://doi.org/10.3390/educsci12070438>.

ILO4	apply proper inventory control methods for a product with known demand	Level_3	proper inventory control methods <i>(inventory, control, type of inventory, ABC analysis, EOQ model, quantity discount model)</i>	a product with known demand <i>(product, demand)</i>
ILO5	choose the best operations scheduling approach to optimize certain shop floor performance indicators	Level_5	the best operations scheduling approach <i>(scheduling, operations, sequencing rules, line balancing)</i>	optimize certain shop floor performance indicators <i>(KPI, performance indicator)</i>
ILO6	describe the principles of push and pull control policies	Level_2	the principles of push and pull control policies <i>(push, pull, control policies)</i>	
ILO7	explain and utilize appropriate lean tools to continuously improve shop floor performance	Level_2 Level_3	appropriate lean tools <i>(lean philosophy, tools, 5S, Toyota production system, wastes, value stream mapping, PDCA, SMED, Kanban)</i>	continuously improve shop floor performance <i>(continuous improvement, performance)</i>
ILO8	apply value stream mapping for current and future states to a given case study	Level_3	value stream mapping for current and future states <i>(value stream mapping, current state, future state, action plan, lead time, capacity analysis, continuous flow, factory layout, product families, heijunka)</i>	a given case study <i>(case study)</i>

Teaching and Learning Activities (TLA)

The template for the formulation of the TLA is emphasizing the following dimensions:

- What is the teacher supposed to do to enact the underlying ILO

- What is the learner supposed to do to enact the underlying ILO
- How does the suggested activity relate to good teaching practices as expressed in the 7 principles of good learning²

Table 2.1: TLAs for the Course: Planning and control, Partner: KTH

ILO reference (Highlight the Verb that need be aligned)	Teaching Activity (What the teachers do)	Learning Activity (What the students do)	How does this use the 7 Principles of good learning
ILO1 explain fundamental principles used in traditional production planning and control systems	TA 1.1 Present the principles used in traditional production planning and control systems. TA1.2 Explain why they are important.	LA 1.1 Listen to the presentation, take notes, and ask questions. LA 1.2 Listen to the presentation, take notes and ask questions. LA 1.3 Discuss the importance of the presented principles.	Encourages contact between students and faculty, LA 1.1 LA1.2 Gives prompt feedback, LA 1.3
ILO2 develop aggregate plans for manufacturing of a multi-component product	TA2.1 Explain aggregate planning for manufacturing multi-component product. TA2.2 Describe and show Examples during class tutorial	LA 2.1 Listen to the presentation, take notes, and ask questions. LA 2.2 Create, apply and evaluate appropriate aggregate planning solutions.	Encourages contact between students and faculty LA 2.1 LA 2.2 Encourages active learning LA 2.2 Gives prompt feedback, LA 2.2 Respects diverse talents and ways of learning TA 2.2 LA 2.2
ILO3 propose and motivate a Master Production Schedule and a Material	TA3.1 Explain MPS and MRP for aggregate planning TA3.2 Describe and show	LA 3.1 Listen to the presentation, take notes, and ask questions. LA 3.2	Encourages contact between students and faculty LA 3.1 LA 3.2 Encourages active learning LA 3.2

² 7 principles of good learning:

- encourages contact between students and faculty,
- develops reciprocity and cooperation among students,
- encourages active learning,
- gives prompt feedback,
- emphasizes time on task,
- communicates high expectations
- respects diverse talents and ways of learning

Arthur W. Chickering and Zelda F. Gamson (1987)

Requirements Plan for a given aggregate plan	Examples during tutorial class.	Apply the explained methods MPS and MRP for aggregate planning and solve the exercises proposed on MPS and MRP.	Gives prompt feedback, LA 3.2 Respects diverse talents and ways of learning TA 3.2 LA 3.2
ILO4 apply proper inventory control methods for a product with known demand	TA 4.1 Explain inventory control methods. TA 4.2 Describe and show Examples during tutorial class	LA 4.1 Listen to the presentation, take notes, and ask questions. LA 4.2 Apply and use the inventory control methods in the given exercises.	Encourages contact between students and faculty LA 4.1 LA 4.2 Encourages active learning LA 4.2 Gives prompt feedback, LA 4.2 Respects diverse talents and ways of learning TA 4.2 LA 4.2
ILO5 choose the best operations scheduling approach to optimize certain shop floor performance indicators	TA 5.1 Explain operations scheduling approaches. TA 5.2 Describe and show Examples during tutorial class	LA 5.1 Listen to the presentation, take notes, and ask questions. LA 5.2 Evaluate and select the best operations scheduling approach for optimizing production performance indicators.	Encourages contact between students and faculty LA 5.1 LA 5.2 Encourages active learning LA 5.2 Gives prompt feedback, LA 4.2 Respects diverse talents and ways of learning TA 5.2 LA 5.2
ILO6 describe the principles of push and pull control policies	TA 6.1 Present the push and pull control principles.	LA 6.1 Listen to the presentation, take notes, and ask questions.	Encourages contact between students and faculty, LA 6.1
ILO7 explain and utilize appropriate lean tools to continuously improve shop floor performance	TA 7.1 Explain lean principles and tools. TA 7.2 Describe and show instructions for lean laboratory sessions	LA 7.1 Listen to the presentation, take notes, and ask questions. LA 7.2 Explain, discuss and apply appropriate lean tools during the lean laboratory sessions.	Encourages contact between students and faculty LA 7.1 LA 7.2 Encourages active learning LA 7.2 Gives prompt feedback, LA 7.2 Respects diverse talents and ways of learning

			TA 7.2 LA 7.2
ILO8 apply value stream mapping for current and future states to a given case study	TA 8.1 Explain value stream mapping tool. TA 8.2 Describe and show instructions for the project	LA 8.1 Listen to the presentation, take notes, and ask questions. LA 8.2 Discuss, explain and use the value stream mapping for a given case study.	Encourages contact between students and faculty LA 8.1 LA 8.2 Encourages active learning LA 8.2 Gives prompt feedback, LA 8.2 Respects diverse talents and ways of learning TA 8.2 LA 8.2

Table 2.2: TAs for the Course: Planning and control, Partner: KTH

Course moment ³	Weekday, date and time slot ⁴	LA Type ⁵	Location ⁶	ILO Code	TLA Code ⁷	Course material ⁸	Keywords	Link to the material
Class	2 hours	Lecture	IRL	ILO1	TA1.1 TA1.2	slides	Production planning, Activities Objectives production control production systems	link
Class	2 hours	Lecture	IRL	ILO1 ILO2	TA1.1 TA1.2 TA2.1	slides	aggregate planning, resource allocation, demand forecasting, cost optimization	link
Class	2 hours	Lecture	IRL	ILO1 ILO4	TA1.1 TA1.2 TA4.1	slides	inventory, control, type of inventory, ABC analysis, EOQ model, quantity discount model	link
Tutorial	2 hours	Tutorial	IRL	ILO2 ILO4	TA2.2 TA4.2	slides	Aggregate planning Inventory control	link
Laboratory	3 hours	Laboratory	IRL	ILO4	TA4.2	Slides	Push control inventory, control, type of inventory, ABC analysis, EOQ model, order point	link
Class	4 hours	Lecture	IRL	ILO1 ILO6 ILO7	TA1.1 TA1.2 TA6.1 TA7.1	slides	lean philosophy, tools, 5S,	link

³ Can be physical meeting or homework or any other kind of activity that need to be done in the course (e.g., visit). It shows the chronological flow of the course.

⁴ It helps understanding relative positioning and duration of different course moments.

⁵ referring to column 3 of the Table 3 (can be one of the listed examples). For more info refer to <https://doi.org/10.3390/educsci12070438>.

⁶ Class, home, lab, company

⁷ Follow the code of the previous template Table 2.1 (TA)

⁸ Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

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							Toyota production system, wates, value stream mapping, PDCA, SMED, Kanban	
Class	2 hours	Lecture	IRL	ILO8	TA8.1	slides	Value stream mapping current state, future state, action plan, lead time, capacity analysis, continuous flow, factory layout, product families, heijunka	link
Project	10 hours (Throughout the course)	Case study Create a new report Group work Problem-solving tasks	IRL Virtual Home	ILO8	TA8.2	Slides Note Task description	value stream mapping, current state, future state, action plan, lead time, capacity analysis, continuous flow, factory layout, product families, heijunka	link
Laboratory	3 hours	Laboratory	IRL	ILO4	TA4.2	Slides	Pull control, inventory, control, type of inventory, ABC analysis, EOQ model, order point	link
Class	2 hours	Lecture	IRL	ILO3	TA3.1	slides	MRP, bill of material, enterprise resource planning, MPS	link
Tutorial	2 hours	Tutorial	IRL	ILO3	TA3.2	slides	MRP, bill of material, enterprise resource planning, MPS	link link
Laboratory	3 hours	Laboratory	IRL	ILO2 ILO ILO7	TA2.2 TA7.2	Slides	Kanban inventory, control, type of inventory, ABC analysis, EOQ model, order point	link
Laboratory	4 hours	Laboratory	IRL	ILO7	TA7.2	-	lean philosophy, tools, 5S, Toyota production system, wates, value stream mapping, PDCA, SMED, Kanban	-
Class	2 hours	Lecture	IRL	ILO5	TA5.1	slides	scheduling, operations, sequencing rules, line balancing KPI	link
Tutorial	2 hours	Tutorial	IRL	ILO5	TA5.2	slides	scheduling, operations, sequencing rules, line balancing KPI	link

Table 3: Learning activities examples (column 3)

Bloom Taxonomy	EGV	Learning Activities (Examples)
Remember	arrange, define, list, identify	Lecture, Reading materials
Comprehension	classify, discuss, present, rewrite	Mind map, Think-pair-share, Discussion, Reflection, Fishbowl
Apply	solve, calculate, demonstrate, organize, use	Case study in real-life situation, Problem-solving tasks, Roleplay, Group work, Laboratory
Analyze	categorize, contrast, compare, debate, inspect	Debates, Class discussion, Jigsaw method, Think-pair-share, Fishbowl, Laboratory
Evaluate	assess, conclude, justify, measure	Journal, Debates, Mind map, Peer evaluation
Create	design, develop, revise, formulate	Brainstorm, Design a presentation, Create a new report, Construct a roleplay

Assessment Task

The template for the formulation of the AT is emphasizing different assessment strategies for different verbs and different learning style.

[Link](#) to material

Table 4: ATs for the Course: Planning and control, Partner: KTH

ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO1 explain fundamental principles used in traditional production planning and control systems	Bloom level: 2 Type***: Exam questions Short description: Answer questions related to the fundamental principles of production planning and control.		
ILO2	Bloom level: 6		

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develop aggregate plans for manufacturing of a multi-component product	Type***: Exam questions Short description: Solve the proposed exercises and design the aggregate plan accordingly (resource allocation, cost optimization)		
ILO3 propose and motivate a Master Production Schedule and a Material Requirements Plan for a given aggregate plan	Bloom level: 3 Type***: Exam questions Short description: Solve the proposed exercises on MRP and MPS.		
ILO4 apply proper inventory control methods for a product with known demand	Bloom level: 3 Type***: Exam questions Short description: Solve the proposed exercises on inventory control (EOQ, order point).	Bloom level: 3 Type***: Laboratory Short description: Analyse and discuss proper inventory control approaches given the proposed production game/simulation.	
ILO5 choose the best operations scheduling approach to optimize certain shop floor performance indicators	Bloom level: 5 Type***: Exam questions Short description: Solve the proposed exercises on operation scheduling to maximise shop floor performance.		
ILO6 describe the principles of push and pull control policies	Bloom level: 2 Type***: Exam questions Short description: Answer questions related to push and pull control.	Bloom level: 2 Type***: Laboratory Short description: Discuss the principles of push and pull control in the given assembly line.	
ILO7 explain and utilize appropriate lean tools to continuously improve shop floor performance	Bloom level: 2-3 Type***: Laboratory Short description: Analyse, explain and discuss proper lean tools to minimise the waste in the given assembly line.		

ILO8	Bloom level: 3		
apply value stream mapping for current and future states to a given case study	Type***: Project		
	Short description: Discuss the inefficiency occurring in the proposed case study. Apply the value stream mapping tool to analyse the given case study. Compile your analysis in a written report.		

Table 5: AT examples

Bloom Taxonomy	EGV	Assessment Task (Examples)
Remember	arrange, define, list, identify	Multiple choice, quiz/test, question banks, take-home examinations
Comprehension	classify, discuss, present, rewrite	Concept/mind maps, interview, debate, problem sheet, minutes, forum posts, open-book, individual presentation, group presentation, viva-voce
Apply	solve, calculate, demonstrate, organize, use	Abstract, case study, problem-solving tasks, roleplay, group work, portfolio, workbook, project
Analyze	categorize, contrast, compare, debate, inspect	Thesis, annotated bibliography, literature review, debates, class discussion, jigsaw method, think-pair-share, fishbowl, laboratory
Evaluate	assess, conclude, justify, measure	Report, reflection, journal, debates, mind map, peer evaluation, group work, teamwork
Create	design, develop, revise, formulate	Project, thesis, article, essay, creative work, demonstration, performance, roleplay, recorded/rendered creative work,

2.4. UNIPI

Intended Learning Outcomes (ILOs)

The template for the formulation of the ILO is emphasizing the student perspective. All the ILO are formulated to address directly what is expected from the learner after following the related educational unit. Three are the key elements:

- **Short description:** ILOs has in general from 150 to 250 characters.
- **Bloom Verb Level:** detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy¹ selecting one of the following level:
 - o Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
 - o Level2_ Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
 - o Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
 - o Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
 - o Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
 - o Level 6_Produce new or original work "Create": (design, assemble, construct, conjecture, formulate, author, investigate)
- **Content** to which the action indicated by the verb refer to and keywords enclosed in parentheses and in italics
- **Context** where the action for the related content must be applied and keywords enclosed in parentheses and in italics

Table 1: ILOs for the Course: Manufacturing processes, Partner: Unipi

	Short description	Bloom Verb level	Content (<i>keywords</i>)	Context (<i>keywords</i>)
ILO 1	Evaluate advanced machining processes and their quality, productivity, and costs in manufacturing environments and operations	Level_5	advanced machining processes and their quality, productivity, and costs (<i>turning, drilling, milling, and grinding</i>)	Chip removal operations (<i>chip removal, manufacturing processes, industrial, industry</i>)
ILO 2	Design and optimize casting processes considering model and core design, gating system, cooling modules, and material properties. Evaluate economic feasibility, identify and rectify common foundry defects, and apply Design for Manufacturing principles.	Level_6	manufacturing, quality and, cost principles of various casting processes (<i>model design, core design, gating system, cooling modules, material properties, feasibility, foundry defects,</i>)	Casting operations
ILO 3	Evaluate metal forming processes through extrusion and rolling techniques,	Level_5	manufacturing, quality and, cost principles of	Metal forming operations

¹ For more info refer to: <https://doi.org/10.3390/educsci12070438>.

	applying principles of deformation and friction analysis, and selecting appropriate equipment for operations like forging and sheet metal processing.		various metal forming processes <i>(extrusion and rolling techniques, principles of deformation and friction analysis, equipment)</i>	
ILO 4	Apply and use metrology concepts such as tolerance, geometric errors, surface texture, precise instruments (calipers, micrometers), and CMMs for accurate inspections, and program measurements effectively	Level_3	Metrology, quality and, cost principles of various inspection processes <i>(tolerance, geometric errors, surface texture, precise instruments (calipers, micrometers), and CMMs)</i>	Metrology and inspection operations
ILO 5	Analyze and evaluate joining techniques in manufacturing such as welding (gas, arc, resistance, brazing, plasma) and related defects	Level_3	manufacturing, quality and, cost principles of various joining processes <i>(welding (gas, arc, resistance, brazing, plasma) and related defects)</i>	Joining operations

Teaching and Learning Activities (TLA)

The template for the formulation of the TLA is emphasizing the following dimensions:

- What is the teacher supposed to do to enact the underlying ILO
- What is the learner supposed to do to enact the underlying ILO
- How does the suggested activity relate to good teaching practices as expressed in the 7 principles of good learning²

Table 2.1: TLAs for the Course: Manufacturing processes, Partner: Unipi

ILO reference (Highlight the Verb that need be aligned)	Teaching Activity (What the teachers do)	Learning Activity (What the students do)	How does this use the 7 Principles of good learning
ILO 1 Evaluate advanced machining processes and their quality, productivity, and costs in manufacturing environments and operations	TA 1.1 Present machining processes in manufacturing	LA 1.1 Listen to the presentation, take notes, and ask questions.	Encourages contact between students and faculty, LA 1.1 LA1.2
	TA 1.2 Explain how chip removal technology can be applied for manufacturing a part	LA 1.2 Listen to the presentation, take notes and ask questions.	Encourages active learning TA 1.3 TA 1.4 LA 1.3 LA 1.4
	TA 1.3 Describe and show a real application of machining processes for manufacturing a part and instructions for the project case	LA 1.3 Apply and evaluate chip removal principles on the project case.	Gives prompt feedback, TA 1.4 LA 1.3 LA 1.4
	TA 1.4 Encourage discussion on the application provided.	LA 1.4 Discuss about the experience on the application provided.	Respects diverse talents and ways of learning TA 1.3 LA 1.3

² 7 principles of good learning:

- encourages contact between students and faculty,
- develops reciprocity and cooperation among students,
- encourages active learning,
- gives prompt feedback,
- emphasizes time on task,
- communicates high expectations
- respects diverse talents and ways of learning

Arthur W. Chickering and Zelda F. Gamson (1987)

ILO2 Design and optimize casting processes considering model and core design, gating system, cooling modules, and material properties. Evaluate economic feasibility, identify and rectify common foundry defects, and apply Design for Manufacturing principles.	TA 2.1 Present casting and solidification processes TA 2.2 Explain how casting process technology can be applied for manufacturing a part TA 2.3 Describe and show a real application of casting processes for manufacturing a part and instructions for the virtual simulation using FEM software TA 2.4 Encourage discussion on the application provided.	LA 2.1 Listen to the presentation, take notes, and ask questions. LA 2.2 Listen to the presentation, take notes and ask questions. LA 2.3 Apply and evaluate casting and solidification principles on the project case. LA 2.4 Discuss about the experience on the application provided.	Encourages contact between students and faculty, LA 2.1 LA2.2 Encourages active learning TA 2.3 TA 2.4 LA 2.3 LA 2.4 Gives prompt feedback, TA 2.4 LA 2.3 LA 2.4 Respects diverse talents and ways of learning TA 2.3 LA 2.3
ILO3 Evaluate metal forming processes through extrusion and rolling techniques, applying principles of deformation and friction analysis, and selecting appropriate equipment for operations like forging and sheet metal processing.	TA 3.1 Present metal forming processes TA 3.2 Explain how metal forming process technology can be applied for manufacturing a part	LA 3.1 Listen to the presentation, take notes, and ask questions. LA 3.2 Listen to the presentation, take notes and ask questions. LA 3.3 Apply and evaluate metal forming principles	Encourages contact between students and faculty, LA 3.1 TA 3.1 LA3.2 TA 3.2 Encourages active learning LA 3.3 Gives prompt feedback, LA 3.3 Respects diverse talents and ways of learning LA 3.3
ILO 4 Apply and use metrology concepts such as tolerance, geometric errors, surface texture, precise instruments (calipers, micrometers), and CMMs for accurate	TA 4.1 Present metrology principles TA 4.2 Explain how metrology technology can be applied for inspecting a part TA 4.3	LA 4.1 Listen to the presentation, take notes, and ask questions. LA 4.2 Listen to the presentation, take notes and ask questions. LA 4.3	Encourages contact between students and faculty, LA 4.1 LA4.2 Encourages active learning TA 4.3 LA 4.3 Gives prompt feedback, LA 4.3

inspections, and program measurements effectively	Describe and show a real application of casting processes for manufacturing a part and instructions for the project	Apply and evaluate metrology principles	Respects diverse talents and ways of learning TA 4.3 LA 4.3
ILO5 Analyze and evaluate joining techniques in manufacturing such as welding (gas, arc, resistance, brazing, plasma) and related defects	TA 5.1 Present joining techniques and principles TA 5.2 Explain how joining technology can be applied for assemble multiple components	LA 5.1 Listen to the presentation, take notes, and ask questions. LA 5.2 Listen to the presentation, take notes and ask questions. LA 5.3 evaluate joining principles	Encourages contact between students and faculty, LA 5.1 TA 5.1 LA5.2 TA 5.2 Encourages active learning LA 5.3 Gives prompt feedback, LA 5.3 Respects diverse talents and ways of learning LA 5.3

Table 2.2: TAs for the Course: Manufacturing processes, Partner: Unipi

Course moment ³	Weekday, date and time slot ⁴	LA Type ⁵	Location ⁶	ILO Code	TLA Code ⁷	Course material ⁸	Keywords	Link to the material
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Orthogonal Cutting Chip Formation Cutting Ratio Cutting Force Cutting Insert Types of Chips Cutting Fluids Tool Insert	link
Homework	3-5 hours	Reading material	Home	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Chapter	Orthogonal Cutting Chip Formation Cutting Ratio Cutting Force Cutting Insert Types of Chips Cutting Fluids Tool Insert	link
Homework	minutes	Reflection	Home	ILO1	TA1.1, TA1.2	Videos	Orthogonal Cutting Chip Formation Cutting Ratio	1. link 2. link

³ Can be physical meeting or homework or any other kind of activity that need to be done in the course (e.g., visit). It shows the chronological flow of the course.

⁴ It helps understanding relative positioning and duration of different course moments.

⁵ referring to column 3 of the Table 3 (can be one of the listed examples). For more info refer to <https://doi.org/10.3390/educsci12070438>.

⁶ Class, home, lab, company

⁷ Follow the code of the previous template Table 2.1 (TA)

⁸ Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

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					LA1.1., LA1.2		Cutting Force Cutting Insert Types of Chips Cutting Fluids Tool Insert	
Class, Homework	1 hour	Discussion, Laboratory	Presence and Home	ILO1	TA1.2 TA1.3 LA1.2 LA1.3	www page	Orthogonal Cutting Chip Formation Cutting Ratio Cutting Force Cutting Insert Types of Chips Cutting Fluids Tool Insert	link
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Oblique Cutting Cutting Parameters Cutting Edge Angles Machining Parameters Measurement Units Surface Roughness Feed per Revolution Corner Radius Registration Angles	link
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Cutting Energy Cutting Power Cutting Pressure Kronenberg's Cutting Force Specific Cutting Energy Single Point Tool Geometry Standardized Tool Angles Main Views and Sections Cutting Angles	link
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Clearance Angles Psi Cutting Edge Chi Registration Lambda Cutting Edge Minimum Uncut Chip Thickness Plowing Chip Breakage Diagram Tool Damage Morphology Tool Wear	link
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Insert Installation ISO Coding Tool Materials CBN (Cubic Boron Nitride) PVD (Physical Vapor Deposition) CVD (Chemical Vapor Deposition) Tool Damage Morphology Tool Wear Evaluation Parameters	link
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Taylor's Law Cost Estimation Active and Idle Times Setup Times Organizational Methods for Efficiency Cost and Time Optimization Economic and Productive Speeds Turning Operations Cylindrical Turning Facing Threading	link
Homework	3-5 hours	Reading material	home	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Chapter	Taylor's Law Cost Estimation Active and Idle Times Setup Times Organizational Methods for Efficiency	1. link 2. link

							Cost and Time Optimization Economic and Productive Speeds Turning Operations Cylindrical Turning Facing Threading	
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Machining Tolerances Process Capability Dimensional Tolerances Surface Finish Hole Machining Helical Drill Bit Cutting Angles and Power Chatter Problem Centering Issue Center Drill Bit Standard and Special Tools Integral and Insert Tools Drilling Operations Anglo-Saxon Nomenclature Tool Catalog and Special Equipment	link
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Reamers and Countersinks Turning Boring Tapping and Rolling Hand and Machine Tools Milling taxonomy Facing Shouldering, Slots, Pockets, Contours Milling Cutter Taxonomy	link
Homework	minutes	Reflection	Home	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Videos	Reamers and Countersinks Turning Boring Tapping and Rolling Hand and Machine Tools Milling taxonomy Facing Shouldering, Slots, Pockets, Contours Milling Cutter Taxonomy	1. link 2. link
Homework	3-5 hours	Reading material	Home	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Chapter	Reamers and Countersinks Turning Boring Tapping and Rolling Hand and Machine Tools Milling taxonomy Facing Shouldering, Slots, Pockets, Contours Milling Cutter Taxonomy	1. link 2. link 3. link
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Evolution of Manual Machine Tools Industrial Revolutions Manual Lathe Schematics Mechanical Components Standard Equipment Tracing Operation Drills Universal Milling Machine Components Configurations Operations Main Equipment	link
Homework	minutes	Reflection	Home	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Videos	Evolution of Manual Machine Tools Industrial Revolutions Manual Lathe Schematics Mechanical Components	link

							Standard Equipment Tracing Operation Drills Universal Milling Machine Components Configurations Operations Main Equipment	
Homework	3-5 hours	Reading material	Home	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Chapter	Evolution of Manual Machine Tools Industrial Revolutions Manual Lathe Schematics Mechanical Components Standard Equipment Tracing Operation Drills Universal Milling Machine Components Configurations Operations Main Equipment	1. link 2. link 3. link 4. link 5. link 6. link
Class	2 hours	Lecture, Discussion	Presence and Virtual	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Video lecture	Cycle Definition Drawing Preliminary Analysis Surface Definition Manufacturing Process Selection Phases and Subphases Breakdown Alternative Cycle Analysis Process Planning Surface Analysis Preliminary Drawing Evaluation Phase Division	link
Class	2 hours	Lecture, Discussion	Presence and Virtual	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Video lecture	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	link
Class	2 hours	Lecture, Discussion	Presence and Virtual	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Video lecture	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	link
Homework	minutes	Reflection	Home	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Videos	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	link
Homework	2-5 hours	Reading material	Home	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Chapter	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	link
Homework	2-5 hours	Create a new report, group work	Home	ILO1	TA1.3, TA1.4	Peer work	Operation Sequence Selection	link

					LA1.3., LA1.4		Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Video lecture	Milling Force and Power Estimation Interrupted Cutting Ball Screw Threads Equipment Comparison Boring Head vs. Reamer vs. Boring Machine Straight-line Machining Broaching Grinding Machine Configuration	link
Homework	minutes	Reflection	Home	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Videos	Milling Force and Power Estimation Interrupted Cutting Ball Screw Threads Equipment Comparison Boring Head vs. Reamer vs. Boring Machine Straight-line Machining Broaching Grinding Machine Configuration	1. link 2. link 3. link 4. link
Homework	3-5 hours	Reading material	Home	ILO1	TA1.1, TA1.2 LA1.1., LA1.2	Chapter	Milling Force and Power Estimation Interrupted Cutting Ball Screw Threads Equipment Comparison Boring Head vs. Reamer vs. Boring Machine Straight-line Machining Broaching Grinding Machine Configuration	1. link 2. link
Visit	2 hours	Laboratory	Lab	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Video lecture	Laboratory Machine Functionality Description Practical Demonstrations Bar Cutting Operations Turning Milling Gear Wheel Production Grinding Drilling	link
Class	2 hours	Lecture	Presence and Virtual	ILO2	TA2.1, TA2.2 LA2.1., LA2.2	Video lecture	Blind Risers Influence Radius Sizing and Attachment Collar End Effect and Chillers Directional Solidification Jet Checks Heuvers Circles Caine Diagram Parting Plane Overshoots Draft Angles Fillet Radii Casting Design Pattern Modifications	link
Homework	3-5 hours	Reading material	Home	ILO2	TA2.1, TA2.2 LA2.1., LA2.2	Chapter	Blind Risers Influence Radius Sizing and Attachment Collar End Effect and Chillers Directional Solidification	1. link 2. link 3. link

							Jet Checks Heuvers Circles Caine Diagram Parting Plane Overshoots Draft Angles Fillet Radii Casting Design Pattern Modifications	
Class	2 hours	Lecture	Presence and Virtual	ILO2	TA2.1, TA2.2 LA2.1., LA2.2	Video lecture	Synthetic Sand Molding Pit Molding Chemical Bonding Molding Thermal Bonding Molding Shell Molding Investment Casting Die Casting Hot Chamber Machine Cold Chamber Machine Gravity Die Casting Foundry Process Comparison Foundry Defects Residual Stresses Design Changes Management	link
Homework	minutes	Reflection	Home	ILO2	TA2.1, TA2.2 LA2.1., LA2.2	Videos	Synthetic Sand Molding Pit Molding Chemical Bonding Molding Thermal Bonding Molding Shell Molding Investment Casting Die Casting Hot Chamber Machine Cold Chamber Machine Gravity Die Casting Foundry Process Comparison Foundry Defects Residual Stresses Design Changes Management	1. link 2. link 3. link 4. link 5. link 6. link
Class	2 hours	Lecture	Presence and Virtual	ILO2	TA2.1, TA2.2 LA2.1., LA2.2	Video lecture	Crystal Structure of Metals Crystal Defects Dislocation Deformation and Motion Grain Size and Orientation Material (An)isotropy Recrystallization Temperature Effect on Strength, Hardness, Ductility, and Residual Stresses Stress-Strain Curve in Elastic and Plastic Range Engineering and True Stress/Strain	link
Homework	3-5 hours	Reading material	Home	ILO2	TA2.1, TA2.2 LA2.1., LA2.2	Chapter	Crystal Structure of Metals Crystal Defects Dislocation Deformation and Motion Grain Size and Orientation Material (An)isotropy Recrystallization Temperature Effect on Strength, Hardness, Ductility, and Residual Stresses Stress-Strain Curve in Elastic and Plastic Range Engineering and True Stress/Strain	1. link 2. link

Class	2 hours	Lecture, Discussion, Laboratory	Presence and Virtual	ILO2	TA2.3, TA2.4 LA2.3., LA2.4	3d models, video lecture	Synthetic Sand Molding Pit Molding Chemical Bonding Molding Thermal Bonding Molding Shell Molding Investment Casting Die Casting Hot Chamber Machine Cold Chamber Machine Gravity Die Casting Foundry Process Comparison Foundry Defects Residual Stresses Design Changes Management	link
Homework	2-5 hours	Create a new report, group work	Home	ILO2	TA2.3, TA2.4 LA2.3., LA2.4	Peer work	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in molding and solidification Selection of casting process Simulation using FEM	link
Class	2 hours	Lecture	Presence and Virtual	ILO3	TA3.1, TA3.2 LA3.1., LA3.2	Video lecture	Plastic Deformation Extrusion Pressure Estimation Slab Analysis Method Upper Bound Method CAE/FEM and Simulation Types of Semi-Finished Products Types of Rolling Mills Rolling Process Beam Deflection Estimation Grain Effects Residual Stresses Defects Friction Entry and Drag Conditions Torque and Power calibration	link
Homework	3-5 hours	Lecture	Home	ILO3	TA3.1, TA3.2 LA3.1., LA3.2	Chapter	Plastic Deformation Extrusion Pressure Estimation Slab Analysis Method Upper Bound Method CAE/FEM and Simulation Types of Semi-Finished Products Types of Rolling Mills Rolling Process Beam Deflection Estimation Grain Effects Residual Stresses Defects Friction Entry and Drag Conditions Torque and Power calibration	link
Homework	minutes	Reflection	Home	ILO3	TA3.1, TA3.2 LA3.1., LA3.2	Videos	Mannessman Method Pellegrino Pass Method Tube Forming Defects in Rolled Materials Sphere Production Rolling Extrusion Die Angle Selection	1. link 2. link 3. link 4. link 5. link

							Forging Molding	
Class	2 hours	Lecture	Presence and Virtual	ILO3	TA3.1, TA3.2 LA3.1., LA3.2	Video lecture	Mannessman Method Pellegrino Pass Method Tube Forming Defects in Rolled Materials Sphere Production Rolling Extrusion Die Angle Selection Forging Molding	link
Class	2 hours	Lecture, Discussion, Problem- solving task	Presence and Virtual	ILO3	TA3.1, TA3.2 LA3.1., LA3.2 LA3.3	Video lecture	Stamping Sheet Metal Processing Bending Deep Drawing Sheet Metal Characterization	link
Homework	minutes	Reflection	Home	ILO3	TA3.1, TA3.2 LA3.1., LA3.2	Videos	Stamping Sheet Metal Processing Bending Deep Drawing Sheet Metal Characterization	1. link 2. link 3. link
Class	2 hours	Lecture	Presence and Virtual	ILO4	TA4.1, TA4.2 LA4.1., LA4.2	Video lecture	Tolerances Macrogeometric Errors Instrument Calibration Certification Statistical Process Control Measurement Tools Microgeometric Measurements Form Errors Surface Texture Roughness Measurement Roughness Tester Profile Sampling Filtering Roughness Parameters Coordinate Measuring Machine (CMM)	link
Homework	2-5 hours	Create a new report, group work	Home	ILO4	TA4.1, TA4.2 LA4.2., LA4.3	Peer work	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Inspection process selection Inspection tool	link
Homework	minutes	Reflection	Home	ILO4	TA4.1, TA4.2 LA4.1., LA4.2	Videos	Tolerances Macrogeometric Errors Instrument Calibration Certification Statistical Process Control Measurement Tools Microgeometric Measurements Form Errors Surface Texture Roughness Measurement Roughness Tester Profile Sampling Filtering Roughness Parameters Coordinate Measuring Machine (CMM) Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria	link

							Inspection process selection Inspection tool	
Class	2 hours	Lecture, Discussion	Presence and Virtual	ILO5	TA5.1, TA5.2 LA5.1., LA5.2, LA5.3	Video lecture	Welding Process Taxonomy Oxyacetylene Welding and Cutting Electric Arc Welding Resistance Welding Soldering Brazing Friction Stir Welding Design for Welding Energy Density Heat Treatments Heat Affected Zone (HAZ) Distortions Residual Stresses Riveting Clinching Crimping Adhesive Bonding	link
Homework	minutes	Reflection	Home	ILO5	TA5.1, TA5.2 LA5.1., LA5.2	Videos	Welding Process Taxonomy Oxyacetylene Welding and Cutting Electric Arc Welding Resistance Welding Soldering Brazing Friction Stir Welding Design for Welding Energy Density Heat Treatments Heat Affected Zone (HAZ) Distortions Residual Stresses Riveting Clinching Crimping Adhesive Bonding	1. link 2. link

Table 3: Learning activities examples (column 3)

Bloom Taxonomy	EGV	Learning Activities (Examples)
Remember	arrange, define, list, identify	Lecture, Reading materials
Comprehension	classify, discuss, present, rewrite	Mind map, Think-pair-share, Discussion, Reflection, Fishbowl
Apply	solve, calculate, demonstrate, organize, use	Case study in real-life situation, Problem-solving tasks, Roleplay, Group work, Laboratory
Analyze	categorize, contrast, compare, debate, inspect	Debates, Class discussion, Jigsaw method, Think-pair-share, Fishbowl, Laboratory
Evaluate	assess, conclude, justify, measure	Journal, Debates, Mind map, Peer evaluation
Create	design, develop, revise, formulate	Brainstorm, Design a presentation, Create a new report, Construct a roleplay

Assessment Task

The template for the formulation of the AT is emphasizing different assessment strategies for different verbs and different learning style.

Material: https://drive.google.com/drive/folders/0Bys-IU_Yv0e_RWIRd1BzTmRoZ0k?resourcekey=0-WKX_zipVKBurMEnu6ynEVg&usp=sharing

Table 4: TAs for the Course: Manufacturing processes, Partner: Unipi

ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO1 Evaluate advanced machining processes and their quality, productivity, and costs in manufacturing environments and operations	Level: Level_5 Type***: Exam question Short description: Answer questions regarding the presented manufacturing applications discussing on the experience had during the lab session and discussed during classes. Solve simple exercises.	Level: Level_5 Type***: Group work Short description: Present the group project report of the manufacturing process of a given mechanical product and Answer questions regarding the choice of machining processes in the project	Level: Level_5 Type***: Oral examination Short description: Answer to theoretical question on machining technologies and material properties. Explain Main differences, pros and cons using comparison methods
ILO2 Design and optimize casting processes considering model and core design, gating system, cooling modules, and material properties. Evaluate economic feasibility, identify and rectify common foundry defects, and apply Design for Manufacturing principles.	Level: Level_3 Type***: Case study (Exam question) Short description: Answer questions regarding casting process on the experience had during the lab session. Solve simple exercises.	Level: Level_6 Type***: Group work Short description: Present the group project report of the manufacturing process of a given mechanical product and Answer questions regarding the choice of casting processes in the project	Level: Level_5 Type***: Discussion (Oral examination) Short description: Answer to theoretical question on casting technologies. Explain Main differences, pros and cons using comparison methods
ILO3 Evaluate metal forming processes through extrusion and rolling techniques, applying principles of deformation and friction analysis, and selecting appropriate equipment for operations	Level: Level_3 Type***: Case study (Exam question) Short description: Answer questions regarding the metal forming process. Solve simple exercises.	Level: Level_3 Type***: Discussion (Oral examination) Short description: Answer to theoretical question on metal forming processes.	

2.5. PRz

Intended Learning Outcomes (ILOs)

The template for the formulation of the ILO is emphasizing the student perspective. All the ILO are formulated to address directly what is expected from the learner after following the related educational unit. Three are the key elements:

- **Short description:** ILOs has in general from 150 to 250 characters.
- **Bloom Verb Level:** detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy¹ selecting one of the following level:
 - o Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
 - o Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
 - o Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
 - o Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
 - o Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
 - o Level 6_Produce new or original work "Create": (design, assemble, construct, conjecture, formulate, author, investigate)
- **Content** to which the action indicated by the verb refer to and keywords enclosed in parentheses and in italics
- **Context** where the action for the related content must be applied and keywords enclosed in parentheses and in italics

Table 1: ILOs for the Data analysis, Partner: PRz

	Short description	Bloom Verb level	Content (<i>keywords</i>)	Context (<i>keywords</i>)
ILO1	describe modern information technologies, such as OLAP, data warehouses, data mining methods, artificial intelligence methods	Level_2	Modern information technologies <i>(OLAP, data warehouse, data mining, artificial intelligence, management desktop)</i>	decision support processes
ILO2	Implement an example management desktop	Level_3	management desktop <i>(management desktop, data visualization, Excel, pivot tables)</i>	Data visualization

¹ For more info refer to: <https://doi.org/10.3390/educsci12070438>.

1

Teaching and Learning Activities (TLA)

The template for the formulation of the TLA is emphasizing the following dimensions:

- What is the teacher supposed to do to enact the underlying ILO
- What is the learner supposed to do to enact the underlying ILO
- How does the suggested activity relate to good teaching practices as expressed in the 7 principles of good learning²

Table 2.1: TLAs for the Course: Data analysis, Partner: PRz

ILO reference (Highlight the Verb that need be aligned)	Teaching Activity (What the teachers do)	Learning Activity (What the students do)	How does this use the 7 Principles of good learning
ILO1 describe modern information technologies, such as OLAP, data warehouses, data mining methods, artificial intelligence methods	TA 1.1 Present modern information technologies, such as OLAP, data warehouses, data mining methods, artificial intelligence methods TA 1.2 Demonstrate the use of data mining methods to discover knowledge from data	LA 1.1 Listen to the presentation, take notes, and ask questions. LA 1.2 Apply selected data mining methods	Encourages contact between students and faculty, LA 1.1 LA1.2 Encourages active learning LA 2.2 Gives prompt feedback, LA 2.2
ILO 2 Implement an example management desktop	TA 2.1 Present the possibilities and role of management desktops in a decision support processes TA 2.2 Demonstrate the use of Excel to visualize data and to design a management desktop	LA 2.1 Listen to the presentation, take notes, and ask questions. LA 2.2 Implement an example management dashboard	Encourages contact between students and faculty, LA 1.1 Encourages active learning LA 2.2

² 7 principles of good learning:

- encourages contact between students and faculty,
- develops reciprocity and cooperation among students,
- encourages active learning,
- gives prompt feedback,
- emphasizes time on task,
- communicates high expectations
- respects diverse talents and ways of learning

Arthur W. Chickering and Zelda F. Gamson (1987)

Table 2.2: TAs for the Course: Data analysis, Partner: PRz

Course moment ³	Weekday, date and time slot ⁴	LA Type ⁵	Location ⁶	ILO Code	TIA Code ⁷	Course material ⁸	Keywords	Link to the material
Class	2	Lecture		ILO1	TA 1.1	slides	OLAP technologies Data mining Multidimensional data analysis	Errore. L'origine riferimento non è stata trovata..
Class	2	Workshop		ILO2	TA 2.1	slides	management desktop, data visualization, Excel, pivot tables	Errore. L'origine riferimento non è stata trovata..
					TA 2.2	slides, data files, Spreadsheet software	management desktop, data visualization, Excel, pivot tables	Errore. L'origine riferimento non è stata trovata.. Errore. L'origine riferimento non è stata trovata..
Homework	4	Problem-solving tasks		ILO1 ILO2	TA 1.2 TA 2.2	-	Data mining management dashboard	

Links to course materials:

1. [data analysis lecture.pptx](#)
2. [dashboard - introduction.pptx](#)
3. Files required to complete the dashboard workshop:
 - a. [dashboard - template.xlsx](#)
 - b. [customers.xlsx](#)
 - c. [continents.xlsx](#)
 - d. [orders.xlsx](#)
 - e. [products.xlsx](#)
4. Dashboard workshop results: [dashboard - result of the classes.xlsx](#)

³ Can be physical meeting or homework or any other kind of activity that need to be done in the course (e.g., visit). It shows the chronological flow of the course.

⁴ It helps understanding relative positioning and duration of different course moments.

⁵ referring to column 3 of the Table 3 (can be one of the listed examples). For more info refer to <https://doi.org/10.3390/educsci12070438>.

⁶ Class, home, lab, company

⁷ Follow the code of the previous template Table 2.1 (TA)

⁸ Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

Table 3: Learning activities examples (column 3)

Bloom Taxonomy	EGV	Learning Activities (Examples)
Remember	arrange, define, list, identify	Lecture, Reading materials
Comprehension	classify, discuss, present, rewrite	Mind map, Think-pair-share, Discussion, Reflection, Fishbowl
Apply	solve, calculate, demonstrate, organize, use	Case study in real-life situation, Problem-solving tasks, Roleplay, Group work, Laboratory
Analyze	categorize, contrast, compare, debate, inspect	Debates, Class discussion, Jigsaw method, Think-pair-share, Fishbowl, Laboratory
Evaluate	assess, conclude, justify, measure	Journal, Debates, Mind map, Peer evaluation
Create	design, develop, revise, formulate	Brainstorm, Design a presentation, Create a new report, Construct a roleplay

Assessment Task

The template for the formulation of the AT is emphasizing different assessment strategies for different verbs and different learning style.

Table 4: TAs for the Course: Data analysis, Partner: PRz

ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO1 describe modern information technologies, such as OLAP, data warehouses, data mining methods, artificial intelligence methods	Bloom level: Level_2 Type***: Exam question Short description: Answer questions on the OLAP cube creation process.		
ILO 2 Implement an example management desktop	Bloom level: Level_3 Type***: Exam question Short description: Demonstrate how to create references between data tables	Bloom level: Level_3 Type***: Exam question Short description: Demonstrate how to create pivot tables and visualize data from these tables	Bloom level: Level_3 Type***: Exam question Short description: Demonstrate how to place data visualization components in a given management desktop

Table 5: AT examples

Bloom Taxonomy	EGV	Assessment Task (Examples)
Remember	arrange, define, list, identify	Multiple choice, quiz/test, question banks, take-home examinations
Comprehension	classify, discuss, present, rewrite	Concept/mind maps, interview, debate, problem sheet, minutes, forum posts, open-book, individual presentation, group presentation, viva-voce
Apply	solve, calculate, demonstrate, organize, use	Abstract, case study, problem-solving tasks, roleplay, group work, portfolio, workbook, project
Analyze	categorize, contrast, compare, debate, inspect	Thesis, annotated bibliography, literature review, debates, class discussion, jigsaw method, think-pair-share, fishbowl, laboratory
Evaluate	assess, conclude, justify, measure	Report, reflection, journal, debates, mind map, peer evaluation, group work, teamwork
Create	design, develop, revise, formulate	Project, thesis, article, essay, creative work, demonstration, performance, roleplay, recorded/rendered creative work,

Intended Learning Outcomes (ILOs)

The template for the formulation of the ILO is emphasizing the student perspective. All the ILO are formulated to address directly what is expected from the learner after following the related educational unit. Three are the key elements:

- **Short description:** ILOs has in general from 150 to 250 characters.
- **Bloom Verb Level:** detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy¹ selecting one of the following level:
 - o Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
 - o Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
 - o Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
 - o Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
 - o Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
 - o Level 6_Produce new or original work "Create": (design, assemble, construct, conjecture, formulate, author, investigate)
- **Content** to which the action indicated by the verb refer to and keywords enclosed in parentheses and in italics
- **Context** where the action for the related content must be applied and keywords enclosed in parentheses and in italics

Table 1: ILOs for the Course: Simulation modelling, Partner: PRz

	Short description	Bloom Verb level	Content (keywords)	Context (keywords)
ILO1	explain the concepts related to modelling continuous-time systems using the system dynamics method	Level_2	modelling the continuous-time systems concepts (modelling, simulation,, continuous-time system)	system dynamics method (systems thinking, system dynamics method)
ILO2	construct a simulation model reflecting the key features and behaviour of the system under analysis	Level_6	simulation model reflecting key features and behaviours (system, model, modelling, simulation system archetypes)	the system under analysis (system, system archetypes)
ILO3	analyse simulation experiment results for continuous-time systems	Level_4	simulation experiment results (simulation experiment)	continuous-time systems (continuous-time system)

¹ For more info refer to: <https://doi.org/10.3390/educsci12070438>.

Teaching and Learning Activities (TLA)

The template for the formulation of the TLA is emphasizing the following dimensions:

- What is the teacher supposed to do to enact the underlying ILO
- What is the learner supposed to do to enact the underlying ILO
- How does the suggested activity relate to good teaching practices as expressed in the 7 principles of good learning²

Table 2.1: TLAs for the Course: Simulation modelling, Partner: PRz

ILO reference (Highlight the Verb that need be aligned)	Teaching Activity (What the teachers do)	Learning Activity (What the students do)	How does this use the 7 Principles of good learning
ILO1 Explain the concepts related to modelling continuous-time systems using the system dynamics method	TA 1.1 Present the system dynamics method. TA1.2 Describe the continuous-time systems modelling.	LA 1.1 Listen to the presentation, take notes, and ask questions. LA 1.2 Listen to the presentation, take notes and ask questions. LA 1.3 Explain the concepts related to modelling continuous-time systems .	Encourages contact between students and faculty, LA 1.1 LA1.2 Gives prompt feedback, LA 1.3
ILO2 Construct a simulation model reflecting the key features and behaviour of the system under analysis	TA2.1 Describe and present the modelling process using system dynamics. TA2.2 Show and explain model formulation for manufacturing and management systems.	LA 2.1 Observe the presentation, take notes, and ask questions. LA 2.2 Implement and discuss appropriate models.	Encourages contact between students and faculty LA 2.1 LA 2.2 Encourages active learning Gives prompt feedback, Develops reciprocity and cooperation among students LA 2.2

² 7 principles of good learning:

- encourages contact between students and faculty,
- develops reciprocity and cooperation among students,
- encourages active learning,
- gives prompt feedback,
- emphasizes time on task,
- communicates high expectations
- respects diverse talents and ways of learning

Arthur W. Chickering and Zelda F. Gamson (1987)

ILO3 Analyse simulation experiment results for continuous-time systems	TA3.1 Show and explain simulation experiments and result analysis for manufacturing and management systems. TA3.2 Show and explain assumptions of the results analysis	LA 3.1 Observe the presentation, take notes, and ask questions. LA 3.2 Interpret the results. Identify decision variables and constraints. Suggest and justify opportunities for model improvement.	Encourages contact between students and faculty' Gives prompt feedback, LA 3.1 LA 3.2 Encourages active learning, Respects diverse talents and ways of learning, Develops reciprocity and cooperation among students LA 3.2
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Table 2.2: TAs for the Course: Simulation modelling, Partner: PRz

Course moment ³	Weekday, date and time slot ⁴	LA Type ⁵	Location ⁶	ILO Code	TLA Code ⁷	Course material ⁸	Keywords	Link to the material
Class	2 hours	Lecture	Class	ILO1	TA1.1	slides	Introduction Systems thinking System dynamics method Causal dependencies Feedback loop	Intro-System dynamics.pptx
Class	2 hours	Lecture	Class	ILO1	TA1.2	slides	Continuous-time system System archetypes Modelling process Mental and structural models	Modelling-System dynamics.pptx
Class	2 hours	Lecture	Class	ILO2	TA2.1	chapter	Vensim PLE presentation Model settings Mathematical model notation Stocks and flows Material and information flow	System dynamics main concepts.pdf
Class	4 hours	Tutorial	Class	ILO2	TA2.2	Slides, chapter	Manufacturing system components Production flow Line balancing Flow discretization Assembly process Enterprise in the market environment Risk factors	System dynamics in manufacturing.pptx Models of the manufacturing system components.pdf

³ Can be physical meeting or homework or any other kind of activity that need to be done in the course (e.g., visit). It shows the chronological flow of the course.

⁴ It helps understanding relative positioning and duration of different course moments.

⁵ referring to column 3 of the Table 3 (can be one of the listed examples). For more info refer to <https://doi.org/10.3390/educsci12070438>.

⁶ Class, home, lab, company

⁷ Follow the code of the previous template Table 2.1 (TA)

⁸ Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

Class	2 hours	Tutorial	Class	ILO3	TA3.1	Open access article	Setting up simulation parameters, Simulation experiment observation Collecting simulation results Quantitative and qualitative analysis	Problems of System Dynamics model development for complex product manufacturing process.pdf
Class	2 hours	Tutorial	Class	ILO3	TA3.2	Chapter	Simulation results interpretation Identification of decision variables and constraints Model improvement opportunities. Solution selection and implementation Model discussion	SD in manufacturing - case study.pdf
Class/ Homework	15 hours (Throughout the course)	Case study in real-life situation Problem-solving tasks Group work	Virtual Home	ILO1 ILO2 ILO3	TA1.1 TA1.2 TA2.1 TA2.2 TA3.1 TA3.2	-	Create a model of specified system Simulate and discuss result Find improvement opportunities Justify the chosen solution	Project 1.pdf

Table 3: Learning activities examples (column 3)

Bloom Taxonomy	EGV	Learning Activities (Examples)
Remember	arrange, define, list, identify	Lecture, Reading materials
Comprehension	classify, discuss, present, rewrite	Mind map, Think-pair-share, Discussion, Reflection, Fishbowl
Apply	solve, calculate, demonstrate, organize, use	Case study in real-life situation, Problem-solving tasks, Roleplay, Group work, Laboratory
Analyze	categorize, contrast, compare, debate, inspect	Debates, Class discussion, Jigsaw method, Think-pair-share, Fishbowl, Laboratory
Evaluate	assess, conclude, justify, measure	Journal, Debates, Mind map, Peer evaluation
Create	design, develop, revise, formulate	Brainstorm, Design a presentation, Create a new report, Construct a roleplay

Assessment Task

The template for the formulation of the AT is emphasizing different assessment strategies for different verbs and different learning style.

Table 4: ATs for the Course: Simulation modelling, Partner: PRz

ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO1 Explain the concepts related to modelling continuous-time systems using the system dynamics method	Bloom level: 2 Type***: Exam question Simulation modelling - assesment test.pdf Short description: Answer questions on the modelling concepts and system dynamics method		
ILO2 Construct a simulation model reflecting the key features and behaviour of the system under analysis	Bloom level: 6 Type***: Project Short description: Study the given system description and develop appropriate simulation model.		
ILO3 Analyse simulation experiment results for continuous-time systems	Bloom level: 4 Type***: Project Short description: Perform simulation experiment analyse results, discuss and implement model improvements.		



Lead Partner



Partners

