Report WP3: A1-A4

Core textbook
content preparation

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Result

Ontology schema for the preparation of the core textbook content, the support tools for the ontology schema implementation, the enhanced core textbook content

Related to

WP3-A1-A4: Core textbook content preparation

Statement of originality

This deliverable contains original unpublished work, except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation, or both.

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Note

For anyone interested in having more information about the project, please see the website at: https://tet-erasmus.eu/

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1. Introduction

This report presents the core textbook preparation developed according to the ontology schema adopted for collecting educational material, aligning with the results of WP3.

The main result of WP3 is the core textbook content. The content includes the traditional textual content, tables, images, charts, diagrams, etc., and is based on the ontology schema. This schema defines basic terms and relations between terms, which enables a semantically rich description of the textbook content. The content is prepared using the support computer tools, which is also defined in this work package. The content is enhanced by additional content not included in the original textbooks and by new multimedia formats and improved pedagogical approaches that serves to increase the attractiveness of the subject fields.

The University of Pisa (UNIPI) is the leading organization and coordinator for this work package.

The report comprises four main sections, each aligned with a related activity (A1-A4).

- Section 2 addresses WP3-A1, namely the " ***WP3-A1: Definition of the ontology schema for textbook content preparation***". In this section, the state of the art of ontology mapping in education is reviewed in conjunction with the acknowledged pedagogical theory of Constructive Alignment (CA), a pillar of the TET project. Based on the results of this state-of-the-art review, the CONstructively ALIgned (CONALI) ontology emerged as the most aligned for this project, although modifications were necessary to meet the TET project's requirements.

- In the subsequent Section 3, related to the second activity (i.e., A2) of WP3 and named "***WP3-A2: Tools for the ontology schema implementation***" the new version of CONALI 3.0 is defined using Protegè, and starting from the CONALIi owl file. For the simplicity of material collection and initial drafting, a Word template aligned with the input required for CONALI 3.0 was created. The results of this activity are the CONALI 3.0 and the template for material collection.

- In Section 4, related to the activity A3 and entitled "***WP3-A3: Preparation of core textbook content***" the material was uploaded to the template format by each partner of the consortium. The results of this activity are the template filled with the consortium information.

- The final step A4 addressed in Section 5 "***WP3-A4: Review of core textbook content and optimizations***", involved the review of the updated material by the leading team of WP3 (UNIPI) and a consortium-wide review in a consortium meeting.

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 CONstructiveALIgment (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-A1: Definition of the ontology schema for textbook content preparation

This activity is based on the state-of-the-art review of the ontology in the field of education (Section 2.2) with specific focus on CA, briefly highlighted in Section 2.1 and recapping the main requirements for TET in Section 2.3.

2.1 Constructive Alignment (CA)

Contemporary education practices are shifting away from traditional methods of imparting knowledge towards a more constructive theory of learning [1]. Such a pedagogical paradigm emphasizes the significance of designing Educational Units (EdU) based on learners' activities rather than instructors' actions. Constructivist models delineate the learning process through two mechanisms: assimilation and accommodation. Assimilation involves integrating new knowledge into existing understanding, while accommodation entails the realignment of potentially incorrect or incomplete pre-existing knowledge in response to newly acquired information [2].

One practical application of this shift is known as CA, which places emphasis on the actions of learners and begins with clearly communicating the Intended Learning Outcomes (ILOs) for a particular EdU. These ILOs consist of content, context, and an Educational Goal Verb (EGV) [3]. The EGV, based on Bloom's Taxonomy [4], represents the core action that learners are expected to master upon completing the educational unit. To implement CA, the ILOs are aligned with EdU activities using the EGV. In other words, the EGV are integrated into Teaching and Learning Activities (TLAs) and evaluated through Assessment Tasks (ATs) [1].

Application of such theory have been recently proposed analyzing the digitalization of engineer curricula [5] and the definition of industrial engineer archetypes [6].

2.2 Ontology Mapping in Education

The exploration of ontologies in the digitalization of learning material has been an extensive endeavor over the past decades.

The educational semantic web, initially conceptualized nearly two decades ago, remains a vibrant research area, emphasizing the benefits of an ontological approach for organizing diverse educational content types [7]. Noteworthy early works, such as OntoEdu in 2004, integrated cutting-edge technologies into an educational architecture, with a core focus on the educational ontology encompassing user adaptation, automatic composition, education service, and content models [8].

Subsequent developments introduced ontological distributed platforms and utilized the OWL language to define ontology schemas, broadening the goals beyond e-learning to encompass knowledge management systems [9,10].

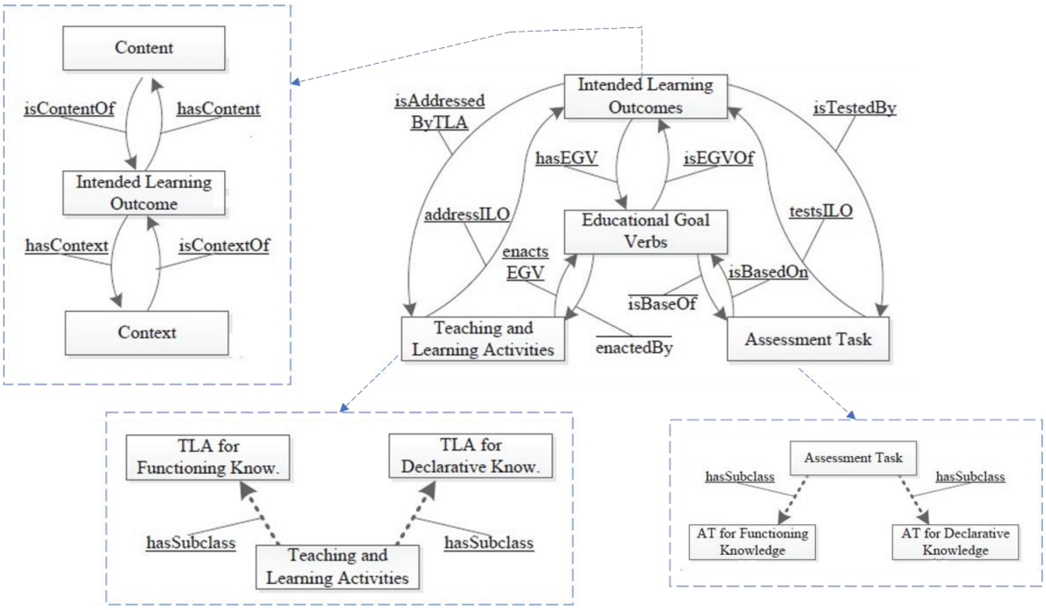
Several works have delved into ontologies for education, with a notable example being the Enhanced Course Ontology for Linked Education (ECOLE). As main contribution, it delves into the use cases and architecture of an educational platform leveraging Linked Open Data [11].

More recent works continue putting effort in the creation of electronic platform for teaching materials and the management of learning information [12,13], focusing on the development of educational ontology, which serves as a vital link between the educational domain, labour market, and personalized learning [14].

Among the reviewed ontologies, the application in education specifically using CA has been solely found in the CONstructiveALIgment (CONALI) ontology proposed by Maffei et. al. (Fig.1) [15]. The adoption of such a model developed using the OWL provides a framework to describe the CA body of knowledge including all the relevant semantic relationships in a computer-readable format [15]. A step further in the adoption of ontology together with CA concepts is proposed in another work published by the same author [16]. In this more recent work, the CONALI ontology is present under a different version "2.0" of such that supports collection and analysis of big educational data from constructively aligned EdUs [16].

CONALI 2.0 model is publicly available[1]. Despite the valuable contribution offered by the CONALI 2.0 ontology, it does not represent the Bloom taxonomy levels of understanding and all the related required kinds of TLA and AT available in literature such as [1]. Finally, CONALI 2.0 does not support fast indexing of the featured content and context.

Fig. 1. CONALI ontology, classes and relations adapted from [15]. Light blue dotted lines show the lower level of granularity for ILOs, TLA and AT classes.



2.3 Results

Table 2 summarizes the retrieved ontologies within the educational context, their contribution to the field and the implementation of CA.

Table 2. Reviewed papers on the application of ontology and CA for educational platforms order in increasing publishing date

Title and reference	Contribution	CA-based
The educational semantic web: Visioning and practicing the future of education [7]	Initial manifesto of education semantic web	no
Ontoedu: Ontology based education grid system for e-learning [8]	Technical and Systemic Perspective on Creating an Ontoedu from a Technological point of view	no

[1]https://unilj.sharepoint.com/:u:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/Report/ConAliOntologyKTHKB.owl?csf=1&web=1&e=ZSUhfi

Exploring e-Learning Knowledge Through Ontological Memetic Agents [9]	The use of ontological representation allows for modeling personalized learning paths (PLP) that define optimal learning experiences	no
Development of an ontology-based e-learning system [10]	Proposal for Implementing Ontology to Structure Educational Material	no
ECOLE: An Ontology-Based Open Online Course Platform [11]	Promotion exchange of the educational content between universities and other organizations, and education ontology examples	no
Web Semantic Technologies in Web Based Educational System Integration [12]	Contribution to corporate E-Learning and a good review of the State of the Art	no
Ontology-based Adaptive e-Textbook Platform for Student and Machine Co-Learning [13]	Contribute to the creation of Architecture of the Electronic Textbook Platform	no
EduCOR: An Educational and Career-Oriented Recommendation Ontology [14]	Attention to FAIR principles for data management and connection between educational and occupational domains	no
CONALI Ontology. A Framework for Design and Evaluation of Constructively Aligned Courses in Higher Education: Putting in Focus the Educational Goal Verbs [15]	OWL ontology presenting constructively alignment as main design principle	yes

In TET project, the focus was on the development of a platform for engineering EdU representation, focusing on CA with relance to Bloom taxonomy instead of the Structure of Observed Learning Outcome (SOLO) taxonomy and without making distinction within declarative and functioning knowledge. 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.

As summarized in Table 2, despite the valuable works among the reviewed ontologies, CONALI is the only one with focus on CA, thus the best to be used in this work given the TET project requirements. However, CONALI does not exactly match with the TET requirements and needs upgrade. In the following Section, CONALI 2.0 is modified and CONALI 3.0 is defined adding the Bloom taxonomy and removing SOLO and some redundance and not necessary information.

3. WP3-A2: Ontology schema implementation

This activity addresses the gap highlighted in the previous activity WP3-A1 (Section 2): i.e., the lack of ready to use CA-based ontologies for education that support collaborative effort. Starting from the CONALI ontology 2.0 the consortium has reshaped the taxonomy and related semantic to match the requirements for the representation of EdU in TET using Protegè and starting from CONALI2.0 OWL file. In addition to that the ontology was expanded also to include a recent contribution in literature that helped mapping and characterizing TLA and AT based on the Bloom taxonomy level they serve: [1]. Finally, the need for indexing the content and context of the ILO was made explicit through the inclusion of specific keywords. The second result of this activity is the template developed in accordance with the new CONALI 3.0 for material collection.

3.1. WP3-A2 Results: The CONALI 3.0

The CONALI 3.0 ontology was modified by (i.e., adding/removing classes, data properties, data object and individuals). As main modification for ILOs class we added: short description, Bloom Verb level, Content (keywords), Context (keywords), and for TLA we added: Course moment, Weekday date and time slot, Location, course material, link to material, keywords. During the ontology restructuring, SOLO taxonomy, functional and declarative knowledge were removed.

In more detail, we removed:

- the class *StructureofObservedLearningOutcome* and the related subclasses *ExtendedAbstractLevelOfUnderstanding*, *Multi-StructuralLevelOfUnderstanding*, *Pre-StructuralLevelOfUnderstanding*, *RelationalLevelOfUnderstanding*, *Uni-StructuralLevelOfUnderstanding*
- the class *KindOfKnowledge* and the related subclasses *DeclarativeKnowledge* and *FunctioningKnowledge*
- the subclasses *ATForDeclarativeKnowledge*, *ATForFunctioningKnowledge* from the class *AssessmentTask*
- the subclasses *TLAForDeclarativeKnowledge*, *TLAForFunctioningKnowledge* from the class *TeachingAndLearningActivities*
- the class *SecondCycleProfile*
- the class *Teacher*

- the class *Programme*

All the related object properties and data properties of the removed classes and subclasses were removed as well. All the ILO and Course instances of CONALI 2.0 were removed. On the other hand, we added:

- data types
    - Short description, string for the ILO
    - ILO_ID, positive integer for the ILO
    - ContentKeyword, string for the content
    - ContextKeyword, string for the context
    - TLAKeywords, string for the TLA
    - TLAMaterialLink, string for the TLA
    - Course_moment, string for the TLA
    - Weekday date and time slot, string for the TLA
    - Location, string for the TLA
- specific sub-classes of AT and TLA classes as identified in the paper recently published. The sub-classes of TLA inherits the father class relation for the EGVs as follows in the object property below.

<*TeachingAndLearningActivity*><enactsEducationalGoalVerbOf><*EducationalGoalVerb*>

<*EducationalGoalVerb*><isEnactedByTLA><*TeachingAndLearningActivity*>*;*

For the existing *TLA* class we added:

- *TLALevel1*: individuals (lecture, Reading material)
- *TLALevel2*: individuals (Mind map, Think-pair-share, Discussion, Reflection, Fishbowl)
- *TLALevel3*: individuals (Case study in real-life situation, Problem-solving tasks, Roleplay, Group work, Laboratory)
- *TLALevel4*: individuals (Debates, Class discussion, Jigsaw method, Think-pair-share, Fishbowl, Laboratory)
- *TLALevel5*: individuals (Journal, Debates, Mind map, Peer evaluation)
- *TLALevel6*: individuals (Brainstorm, Design a presentation, Create a new report, Construct a roleplay)

For the existing *AT* class we added:

- *ATLevel1*: individuals (Multiple choice, quiz/test, question banks, take-home examinations)
- *ATLevel2*: individuals (Mind maps, interview, debate, problem sheet, minutes, forum posts, open-book, individual presentation, group presentation, viva-voce
- *ATLevel3*: individuals (Abstract, case study, problem-solving tasks, roleplay, group work, portfolio, workbook, project)
- *ATLevel4*: individuals (Thesis, annotated bibliography, literature review, debates, class discussion, jigsaw method, think-pair-share, fishbowl, laboratory)
- *ATLevel5*: individuals (Report, reflection, journal, debates, mind map, peer evaluation, group work, teamwork)
- *ATLevel6*: individuals (project, thesis, article, essay, creative work, demonstration, performance, roleplay)

- *BloomTaxonomyLevel* class and related sub-classes for each of the six levels: *BTLevel1*, *BTLevel2*, *BTLevel3*, *BTLevel4*, *BTLevel5*, *BTLevel6* taking as reference. The adopted approach for object properties is to link each BTLevel subclass to each EGV subclass. Then the following object properties were defined.

< *BTLevel1*> <hasRemberingVerb> <*RememberingVerb*>

<*RememberingVerb*> <BelongsToBTLevel1> < *BTLevel1*>;

< *BTLevel2*> <hasUnderstandingVerb> < *UnderstandingVerb*>

<*UnderstandingVerb*> <BelongsToBTLevel2> < *BTLevel2*>;

< *BTLevel3*> < hasApplyingVerb> <*ApplyingVerb*>

<*ApplyingVerb*> <BelongsToBTLevel3> < *BTLevel3*>;

< *BTLevel4*> <hasAnalysingVerb> <*AnalysingVerb*>

<*AnalysingVerb*> <BelongsToBTLevel4> < *BTLevel4*>;

< *BTLevel5*> <hasEvaluatingVerb> <*EvaluatingVerb*>

< *EvaluatingVerb* > <BelongsToBTLevel5> < *BTLevel5*>;

< *BTLevel6*> <hasCreatingVerb> <*CreatingVerb*>

<*CreatingVerb*> <BelongsToBTLevel6> < *BTLevel6*>;

Figure 2 and 3 depict the classes and relations according to the modifications for the TLA/AT and BTLevel, respectively. The CONALI 3.0 ontology in the OWL format is publicly available[2].

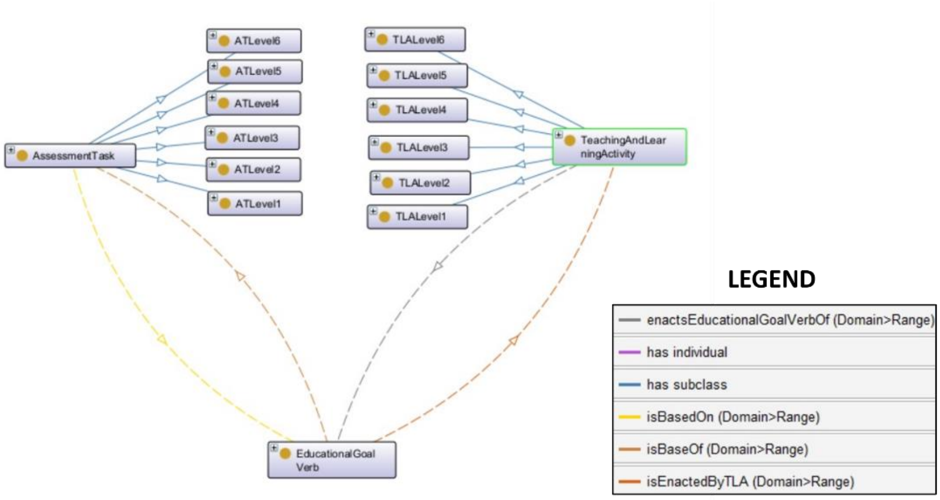


Fig. 2. CONALI 3.0 ontology AT and TLA classes and subclasses and relations

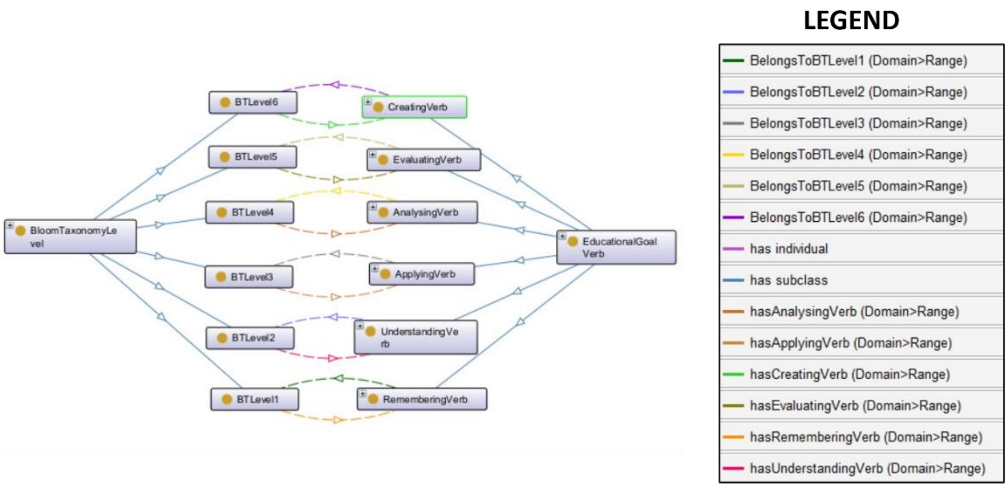


Fig. 3. CONALI 3.0 ontology BTlevl classes and subclasses and relations

[2]https://unilj.sharepoint.com/:u:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/Report/V2_Ontology_CONALI_3.0?csf=1&web=1&e=JO10c3

3.2. WP3-A2 Results: The template for CONALI 3.0

The base to collect the educational material was the template format developed in accordance with the CONALI 3.0 developed in Section 3.1. The template is attached in the following and can be accessed online [3].

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 taxonomy[1] selecting one of the following level:
  - Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
  - Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
  - Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
  - Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
  - Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
  - 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 CourseXX, Partner: XX

	Short description	Bloom Verb level	Content (*keywords*)	Context (*keywords*)
ILO1				
ILO n				

[1] For more info refer to: https://doi.org/10.3390/educsci12070438.

1

[3] https://unilj.sharepoint.com/:w:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A3%20Preparation%20of%20core%20textbook%20content/EduMaterialDataBase_Template.docx?d=wa869b399b6fe42c5a2c33f24903b86d2&csf=1&web=1&e=VMeQ2F

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 learning[2]

Table 2.1: TLAs for the Course: XX, Partner: XX

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	TA 1.1 TA1.2	LA1.1 LA1.2	
ILOn			

Table 2.2: TAs for the Course: XX, Partner: XX

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

[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)

[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

2

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: Manufacturing processes, Partner: Unipi

ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO 1	**Bloom level**: **Type*****: **Short description**:		

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,

4. WP3-A3: Preparation of core textbook content

4.1. Results

During this activity, the partner involved in the project collected EdU information following the template developed in accordance to the CONALI 3.0 (Section 3.2). 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: UNILJ[4] (Appendix)
2. I) *Assembly technology*; II) *Planning and control*, Partner: KTH [5] (Appendix)
3. I) *Manufacturing processes*, Partner: UNIPI[6] (Appendix)
4. I) *Data analysis*; II) *Simulation modelling*, Partner: PRZ[7] (Appendix)

[4] 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
[5] 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=LTVCGG
[6] 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
[7] 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=kI4rN3

5. WP3-A4: Review of core textbook content and optimizations

5.1. Results

The result of this activity is the following report on how to improve the core textbook content. The main result of this activity is the report on the core textbook content analysis. The report has been prepared by the leading partner with the contribution of the other partners in a consortium meeting to cross-validate and review the uploaded material in the templates after the first round, as well as separate check from the leading organization in accordance with the ontology schema.

The report includes two main sections, namely improvements and optimizations of the i) ontology schema and the ii) textbook content.

i) ***Ontology schema improvements***: The CONALI 3.0 has been approved by the consortium (Fig. 4). Additional improvements can occur in the following stage of the project but the current release fits with the expected result, so no specific improvements have been identified. However, a way to improve the overall linkage of the CONALI 3.0 ontology in the TET platform is trying to define a new ontology (from technical perspective) that defines the main aspects, functions and relations of the platform itself with the CONALI one. This ontology (or other formal definition) will be developed during the technical WP4 as initial design stage of the platform itself to establish the linkage of WP3 and WP4. The design of these aspects will also be based on the outcome from WP2 for technical decisions on main functionalities of the platform.

An inception idea was introduced during the initial meeting of the project and a draft of the ontology development is reported in Figure 4, highlighting the current stage of development that cover the right part (with the green CONALI3.0 label) of the schema, while the left (question mark and pink label) and the need to link left and right will be addressed WP4.

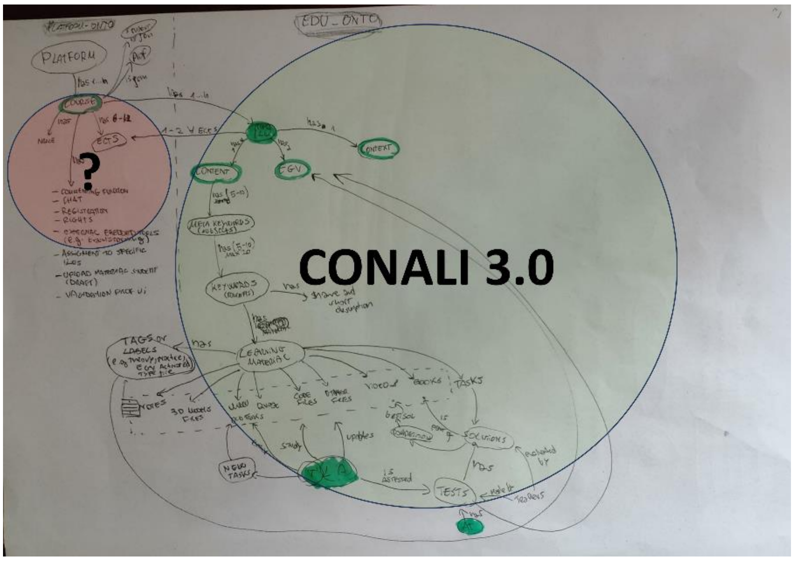


Fig. 4. Drafted CONALI 3.0 ontology linkage to the platform architecture during the initial meeting of WP3. The green part is developed in WP3-A2 and material added in WP3-A3 and optimized in WP3-A4. The pink part will be addressed in WP4 during the initial design stage of the platform to ensure linkage between CONALI3.0 and the platform architecture.

ii) ***Textbook content improvements***: Several issues have been identified during the consortium meeting and during the leading partner review. Among the most important the following topics have been identified with high relevance for the development of the platform and the improvement of the core textbook content:

How to manage the accessibility of data? Is this material public (most universities have copyright issues on the Teaching and Learning material)? Discuss GDPR issues (it can be anonymous contribution; the registration will be with official university email but will be hidden and student can use a nickname) and Licensing for the content (creative common license). Proposed solution concerns the creation of a "accessibility right classification" table where each file updated from the consortium was classified as public (licensed under a Creative Commons Attribution Non-Commercial Share Alike 4.0 International License) or private. The table can be accessed in the Shared drive[8]. This information will be used in the design of the platform and accessibility right for the material in WP4. As other point

[8] https://unilj.sharepoint.com/:x:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A4%20Review%20of%20core%20textbook%20content%20and%20optimizations/Accessability%20right%20classification.xlsx?d=wde084285526140c1a18aaf733ac81f60&csf=1&web=1&e=DGoHOT

to be discussed in WP4 is the file format (e.g., PDF where possible) and language (e.g., using Google Translate for not English material).

After a second round of material update for all the consortium partners, specific recommendations are reported below:

- UNIPI (Manufacturing processes): Overall all the fields of the table are well-completed and rich in information. If possible, add additional material and related links (e.g., book chapters or slides). If possible, add the links to the written test in the AT template.
- PRZ (Data analysis; Simulation modelling,): Add the links to the material highlighted in the template. If possible, add the links of the written test to the AT template. The remaining fields of the table are well-completed and rich in information.
- KTH (Assembly technology; Planning and control): Overall all the fields of the table are well-completed and rich in information. Both the courses are well done. If possible, add additional material and related links. If possible, add the links of the written test to the AT template.
- UNILJ (Mechatronic Actuators). Add the links to the material highlighted in the template. If possible, add the links to the written test to the AT template. The remaining fields of the table are well-completed and rich in information.

During the last meeting the updated materials according to the above guidelines were presented by each partner and the final cross-validation was performed. Final reviewed material was collected as part of the WP3-A4 output[9] and can be accessed in Appendix for each consortium member (KTH need update).

[9] https://unilj.sharepoint.com/:f:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A4%20Review%20of%20core%20textbook%20content%20and%20optimizations?csf=1&web=1&e=TdqumS

6. Appendix

6.1. 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 taxonomy[1] selecting one of the following level:
    - Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
    - Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
    - Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
    - Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
    - Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
    - 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 (*keywords*)	Context (*keywords*)
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 *(actuators, characteristics, comparison)*	selection of a suitable actuator for a particular application *(mechatronic application, suitable actuator, costs, environmental conditions, operating conditions)*
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 *(signal processing, control and regulation, power management, sensing and feedback, heat dissipation, protection)*

[1] For more info refer to: https://doi.org/10.3390/educsci12070438.
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			(semiconductor, semiconductor elements, diode, transistor, thyristor)	
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 *(drives, linear systems, motion, displacement, velocity, acceleration, velocity profile, displacement, precision and accuracy, axes, bearings, couplings)*	implementation of drives for mechatronic applications on different platforms *(mechatronic application, drive solutions, development platforms)*
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 *(control system, modelling, open-loop control, closed-loop control and regulation, controller, PID control)*	mechatronic actuator used in a closed- loop system for precise and stable control according to specified requirements for the time behaviour of a system *(actuator precise and stable control, operating requirements, time behaviour)*

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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 learning[2]

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)

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	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

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	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

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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
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							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

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							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

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					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

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					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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							PID control	
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	Alternative drives for mechatronic actuators Piezoelectric materials Piezoelectric motors Shape memory-based alloy actuators Solenoids	SLIDES

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

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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.		

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,

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6.2. 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 taxonomy[1] selecting one of the following level:
  - Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
  - Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
  - Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
  - Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
  - Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
  - 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 (*keywords*)	Context (*keywords*)
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 (*assembly process, assembly line*)	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 (*modelling, assembly feature, parameters, constraints, tolerances*)	design and evaluation of assembly systems (*design, assembly system*)
ILO3	account for the dynamic and static constraints of a manual or automatic assembly process	Level_4	the dynamic and static constraints (*constraints, dynamic, static*)	a manual or automatic assembly process (*assembly process, manual assembly, automatic assembly*)

[1] For more info refer to: https://doi.org/10.3390/educsci12070438.
1

ILO4	analyse a given product and define feasible assembly sequences	Level_4	Feasible assembly sequences (*assembly sequences, product analysis, workflow analysis*)	Given product
ILO5	choose the best sequence by applying technical and economic criteria	Level_4	Best sequence applying technical and economic criteria (*sequence analysis, technical criteria, economic criteria*)	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 (*function, element*)	an assembly system (both automatic and manual) (*assembly system, manual assembly, automatic assembly*)
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 (*DFA, product design, impact, design efficiency*)	on the assembly process *(assembly process)*
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 *(Assembly sequence, assembly requirements, design requirement*)	Assembly station *(assembly station)*
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) *(KPI, cost, economic performance*)	standard assembly systems (both manual and automatic) *(standard assembly system, manual assembly, automatic assembly*)

2

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 learning[2]

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)

3

			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

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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

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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
6

							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

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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		

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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,

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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 taxonomy[1] selecting one of the following level:
  - Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
  - Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
  - Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
  - Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
  - Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
  - 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 (*production planning, production control, scheduling, inventory management, demand forecasting, capacity planning, production efficiency*)	in traditional production planning and control systems (*production planning, production control*)
ILO2	develop aggregate plans for manufacturing of a multi-component product	Level_6	aggregate plans (*aggregate planning, resource allocation, demand forecasting, cost optimization*)	manufacturing of a multi-component product (*multi-component product*)
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 (*MRP, bill of material, enterprise resource planning, MPS*)	a given aggregate plan

[1] For more info refer to: https://doi.org/10.3390/educsci12070438.
1

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

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

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- 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 learning[2]

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)

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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

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			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

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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.

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.		

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

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6.3. 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 taxonomy[1] selecting one of the following level:
  - Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
  - Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
  - Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
  - Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
  - Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
  - 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 (*keywords*)	Context (*keywords*)
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 (*turning, drilling, milling, and grinding*)	Chip removal operations (*chip removal, manufacturing processes, industrial, industry*)
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 (*model design, core design, gating system, cooling modules, material properties, feasibility, foundry defects,*)	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.
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	applying principles of deformation and friction analysis, and selecting appropriate equipment for operations like forging and sheet metal processing.		various metal forming processes (*extrusion and rolling techniques, principles of deformation and friction analysis, equipment*)	
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 *(tolerance, geometric errors, surface texture, precise instruments (calipers, micrometers), and CMMs)*	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 *(welding (gas, arc, resistance, brazing, plasma) and related defects)*	Joining operations

2

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 learning[2]

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 TA 1.2 Explain how chip removal technology can be applied for manufacturing a part TA 1.3 Describe and show a real application of machining processes for manufacturing a part and instructions for the project case TA 1.4 Encourage discussion on the application provided.	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 chip removal principles on the project case. LA 1.4 Discuss about the experience on the application provided.	Encourages contact between students and faculty, LA 1.1 LA1.2 Encourages active learning TA 1.3 TA 1.4 LA 1.3 LA 1.4 Gives prompt feedback, TA 1.4 LA 1.3 LA 1.4 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)

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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

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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

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							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

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							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

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					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

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							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

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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

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							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

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							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

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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_RWlRd1BzTmRoZ0k?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
ILO 1 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.	

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6.4. 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 taxonomy[1] selecting one of the following level:
    - Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
    - Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
    - Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
    - Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
    - Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
    - 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 (*keywords*)	Context (*keywords*)
ILO1	describe modern information technologies, such as OLAP, data warehouses, data mining methods , artificial intelligence methods	Level_2	Modern information technologies *(OLAP, data warehouse, data mining, artificial intelligence, manage-ment desktop)*	decision support processes
ILO2	Implement an example management desktop	Level_3	management desktop *(management desktop, data visualization, Excel, pivot tables)*	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 learning[2]

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)

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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	TLA 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
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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: 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

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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,

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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 taxonomy[1] selecting one of the following level:
    - Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)
    - Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)
    - Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)
    - Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)
    - Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)
    - 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.
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 learning[2]

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)

2

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

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	Modeling-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, quiz, code, video lecture, book, chapter, task, video, slides, peer work
3

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 discusion	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

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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.		

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