

## **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

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### Note

For anyone interested in having more information about the project, please see the website at: <a href="https://tet-erasmus.eu/">https://tet-erasmus.eu/</a>



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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 CONALI 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.

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

 Table 1: Acronyms, full name, and short descriptions





		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

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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].

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CONALI 2.0 model is publicly available<sup>1</sup>. 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

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





The use of ontological representation allows for modeling personalized learning paths (PLP) that define optimal learning experiences	no
Proposal for Implementing Ontology to Structure Educational Material	no
Promotion exchange of the educational content between universities and other organizations, and education ontology examples	no
Contribution to corporate E- Learning and a good review of the State of the Art	no
Contribute to the creation of Architecture of the Electronic Textbook Platform	no
Attention to FAIR principles for data management and connection between educational and occupational domains	no
OWL ontology presenting constructively alignment as main design principle	yes
	The use of ontological representation allows for modeling personalized learning paths (PLP) that define optimal learning experiences Proposal for Implementing Ontology to Structure Educational Material Promotion exchange of the educational content between universities and other organizations, and education ontology examples Contribution to corporate E- Learning and a good review of the State of the Art Contribute to the creation of Architecture of the Electronic Textbook Platform Attention to FAIR principles for data management and connection between educational and occupational domains OWL ontology presenting constructively alignment as main design principle

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
  - $\circ$  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:

- o *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)
- o *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> < *BTLevel*6>;





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<sup>2</sup>.



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

<sup>&</sup>lt;sup>2</sup>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

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## 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  $^{3}$ .

<ul> <li>Short description: ILOs has in general from 150 to 250 characters.</li> <li>Bloom Verb Level: detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy<sup>1</sup> selecting one of the following level:         <ul> <li>Level1_Recall facts and basic concepts "Remember": (define, duplicate, list, memorize, repeat, state)</li> <li>Level2_Explain ideas or concepts "Understand": (classify, describe, discuss, explain, identify, locate, recognize)</li> <li>Level3_Use information in new situations "Apply": (execute, implement, solve, use, demonstrate, interpret, operate)</li> <li>Level4_Draw connections among ideas "Analyse": (differentiate, organize, relate, compare, distinguish, examine, test, analyze)</li> <li>Level5_Justify a stand or decision "Evaluate": (appraise, argue, defend, judge, select, support, value, critique, weigh)</li> <li>Level 6_Produce new or original work "Create": (design, assemble, construct, conjecture, formulate, author, investigate)</li> </ul> </li> <li>Content to which the action indicated by the verb refer to and keywords enclosed in parentheses and in italics</li> </ul>								
Context where the action for the related content must be applied and keywords enclosed in parentheses and in italics     Fable 1: ILOs for the CourseXX, Partner: XX     Short description Bloom Verb level Content (keywords) Context (keywords)								
ILO1								
ILO1								
ILO1 ILO n		ILO n						

 $<sup>^{3}\</sup> https://unilj.sharepoint.com/:w:/r/sites/ErasmusTETproject/Shared\%20 Documents/WP3-Core-Textbook-Content-Preparation/WP3-Core-Textbook-Preparation/WP3-Core-Textbook-Preparation/WP3-Core-Textbook-Preparation/WP3-Core-Textbook-Preparation/WP3-Core-Textbook-Preparation/WP3-Core-Textbook-Prepa$ 

A3%20Preparation%20of%20core%20textbook%20content/EduMaterialDataBase\_Template.docx?d=wa869b399b6fe42c5a2c33f24903b86d2&csf=1&web=1 &e=VMeQ2F





e templat	te for the	formulatio	n of the	TLA is em	phasizir	ng the foll	owing dim	ensions:	
- Wh	at is the	teacher sup	posed to	do to en	act the	underlyin	g ILO		
- Wh	at is the	learner sup	posed to	do to en	act the u	underlying	( ILO		
- Hov	w does th	e suggester	d activity	relate to	good te	aching pr	actices as	expressed in t	he 7 principles
		ining (	V. Denter						
ible 2.1: T	LAS JOF TR	ie Course: X	x, Partne	er: XX					
O referen	ce	Teaching A	tivity	Learnin	e Activity	(What	How do	es this use the 7	Principles of
Highlight t	he Verb	(What the t	eachers	the stud	dents do)	(	good lea	arning	i incipies ei
hat need b ligned)	e	do)							
LO1		TA 1.1		LA1.1					
		TA1.2		LA1.2			_		
							+		
_							1		
LOn									
ble 2.2: T	As for the	e Course: XX	, Partner	: XX	10	TIA	Course	Keywords	Link to
ioment <sup>a</sup>	and time slo	ot 4	~   ~	cation.	Code	Code <sup>7</sup>	material®	inc protos	the
									material
			-						
principles	of good l	earning:	on stude	nts and fa	culty				
<ul> <li>deve</li> </ul>	elops reci	procity and c	ooperatio	n among	students,	,			
• enco	ourages a	ctive learning	2,						
<ul> <li>give</li> <li>emp</li> </ul>	s prompt phasizes ti	me on task,							
• com	municate	s high expec	tations						
<ul> <li>resp</li> </ul>	ects diver	rse talents ar	nd ways o	flearning		Arth	ur W. Chie	kering and Zelda	E. Gamson (1987)
an be phys	sical meet	ing or home	work or a	ny other k	ind of act	tivity that r	need to be	done in the cou	rse (e.g., visit). It
ows the ch	ronologic	al flow of the	e course.	and durate	on of diff				
eferring to	column 3	of the Table	3 (can be	e one of th	e listed e	examples).	For more i	nfo refer to	
tps://doi.o	rg/10.339	0/educsci12	070438.						
lass, home ollow the o	ab, com code of th	pany e previous te	emplate T	able 2.1 (1	(A)				
Aaterial su	pporting e	each course i	noment.	Can be: 3d	d models,	www page	e, note, qui	izz, code, video l	ecture, book,
apter, task	, video, sl	ides, peer w	ork						
able 3: Lei	arning ac	tivities exar	nples (co	lumn 3)					
Bloom Ta	xonomy		EGV	1			Learning	g Activities (Exampl	les)
Remen	nber	arra	nge, define,	list, identify	t.e	Mind	Lectur map, Think-	e, Reading materials pair-share, Discussio	s on, Reflection,
and the second sec	nension	classif	y, uiscuss, p	strate creat	ine ure	Case st	udy in real-lif	Fishbowl fe situation, Problem	a-solving tasks,
Compreh	(mg/ )	scave, cascil	COLUMN AND ADDRESS AND ADDRESS	The second se	aste, use		Poloidan (	Group work, Labora	abory
App	N.20	categorize o	antrast com	nane debate	inspect	Debates, O	Class discussi	on, Jigsaw method,	Think-pair-share,
Compreh App Analy Evalu	yze aate	categorize, co assess,	ontrast, com conclude, ju	pare, debate ustify, measu	, inspect ire	Debates, O	Class discussi Fish urnal, Debate	on, Jigsaw method, abowl, Laboratory s, Mind map, Peer e	Think-pair-share, valuation





	Asses	sment Task	
he template for th ad different learni	ne formulation of the AT is emphing style	asizing different assessment	strategies for different ve
able 4: TAs for the	Course: Manufacturing process	es, Partner: Unipi	
ILO reference (Highl Verb)	light the Assessment task 1	Assessment task 2	Assessment task n
ILO 1	Bloom level:		
	Tune***.		
	Type .		
	Short description:		
	Short description:		~
	Short description:		
	Short description:		
	Short description:		
able 5: AT example	Short description:		
able 5: AT example Bloom Taxonomy	Short description:	Assessment T	ask (Examples)
able 5: AT example Bloom Taxonomy Remember	ES EGV arrange, define, list, identify	Assessment T Multiple choice, quiz/test, questi	ask (Examples) m banks, take-home examinations
able 5: AT example Bloom Taxonomy Remember Comprehension	ES EGV arrange, define, list, identify classify, discuss, present, rewrite	Assessment T Multiple choice, quiz/test, questi Concept/mind maps, individues, individues forum posts, open-book, individue	ask (Examples) m banks, take-home examinations lebate, problem sheet, minutes, al presentation, group
able 5: AT example Bloom Taxonomy Remember Comprehension Apply	ES EGV arrange, define, list, identify classify, discuss, present, rewrite solve, calculate, demonstrate,	Assessment T Multiple choice, quiz/test, questi Concept/mind maps, interview, c forum posts, open-book, individu presentation, viva-voce Abstract, case study, problem-solv	ask (Examples) on banks, take-home examinations lebate, problem sheet, minutes, al presentation, group ring tasks, roleplay, group work,
able 5: AT example Bloom Taxonomy Remember Comprehension Apply Analyze	ES EGV arrange, define, list, identify classify, discuss, present, rewrite solve, calculate, demonstrate, organize, use categorize, contrast, compare, debate	Assessment T Multiple choice, quiz/test, questi Concept/mind maps, interview, c forum posts, open-book, individu presentiation, viva-voce Abstract, case study, problem-solo portfolio, workbook, project Thesis, annotated bibliography, li	ask (Examples) on banks, take-home examinations (Easte, problem sheet, minutes, al presentation, group ving tasks, roleplay, group work, terature review, debates, class mischen Chikong I biotecom
able 5: AT example Bloom Taxonomy Remember Comprebension Apply Analyze Evaluate	ES EGV arrange, define, list, identify classify, discuss, present, rewrite solve, calculate, demonstrate, organize, use categorize, contrast, compare, debate inspect assess, conclude, justify, measure	Assessment T Multiple choice, quiz/test, questi Concept/mind maps, interview, c forum posts, open-book, individu presentation, viva-voce Abstract, case study, problem-solo portfolio, workbook, project Desis, annotated bibliography, lii discussion, jigsaw method, think- Report, reflection, journal, debate	ask (Examples) on banks, take-home examinations (lebate, problem sheet, minutes, al presentation, group ring tasks, roleplay, group work, terature review, debates, class pair-share, fishbowl, laboratory a, mind map, peer evaluation,





## 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) <u>Mechatronic Actuators</u>, Partner: UNILJ<sup>4</sup> (Appendix)
- 2. I) Assembly technology; II) Planning and control, Partner: KTH<sup>5</sup> (Appendix)
- 3. I) *Manufacturing processes*, Partner: UNIPI<sup>6</sup> (Appendix)
- 4. I) *Data analysis*; II) *Simulation modelling*, Partner: PRZ<sup>7</sup> (Appendix)

<sup>&</sup>lt;sup>4</sup> 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 <sup>5</sup> 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 <sup>6</sup> 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=LTVCGG <sup>6</sup> 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 <sup>7</sup> 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 <sup>7</sup> https://unilj.sharepoint.com/:f:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A3%20Preparation%20of%20core%20textbook%20Content/PRZ?csf=1&web=1&e=Kl4rN3





## 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<sup>8</sup>. This information will be used in the design of the platform and accessibility right for the material in WP4. As other point

<sup>&</sup>lt;sup>8</sup> https://unilj.sharepoint.com/:x:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-

A4%20 Review%20 of%20 core%20 textbook%20 content%20 and%20 optimizations/Accessability%20 right%20 cl assification.xlsx?d=wde084285526140 cla18aaf733 ac81f60 & 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<sup>9</sup> and can be accessed in Appendix for each consortium member (KTH need update).

<sup>&</sup>lt;sup>9</sup> https://unilj.sharepoint.com/:f:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-

A4% 20 Review % 20 of % 20 core % 20 text book % 20 content % 20 and % 20 optimizations? csf=1 & web=1 & e=T dqum State web and % 20 and % 20 optimizations % 20 optimization





## 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<sup>1</sup> 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,	Level 4: analyse,	pneumatic actuators,	selection of a suitable
	hydraulic and electric	compare	hydraulic actuators,	actuator for a particular
	actuators and select a suitable	Level 5: evaluate,	electric actuators,	application
	actuator for a particular	select	characteristics, actuators	
	application in terms of cost,		cost, environmental	(mechatronic application,
	environmental conditions and		conditions, operating	suitable actuator, costs,
	operating conditions.		conditions	environmental conditions,
				operating conditions)
			(actuators,	
			characteristics,	
			comparison)	
ILO2	Understand the role of	Level 2:	semiconductor elements	use of semiconductor
	different electronic	understand	for mechatronic	elements in mechatronic
	semiconductor elements for	Level 3: apply,	actuators, diodes,	actuator applications
	mechatronic actuators and	implement	transistors, thyristors,	
	implement them.		silicon controlled	(signal processing, control
			rectifiers, insulated-gate	and regulation, power
			bipolar transistor,	management, sensing and
			characteristics	feedback, heat dissipation,
				protection)

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





			(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)





### 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<sup>2</sup>

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

<sup>2</sup> 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

3

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





	depending on the	the laboratory and	learning
	application.	discuss the selection of	LA 1.3
		actuators.	LA 1.4
ILO2	TA 2.1	LA 2.1	Encourages contact between students
Understand the	Present semiconductor	Listen to the	and faculty
role of different	elements.	presentation.	LA 2.1
electronic		take notes, and ask	LA 2.2
semiconductor	TA 2.2	questions	
elements for	Explain and show	questions	Develops cooperation among students
mechatronic	where and how are	1422	
actuators and	semiconductor	Listen to the	672.5
implement them	elements used for	presentation	Encourages active learning
implement them.	mechatronic	take notes and ask	
	applications	questions	
	applications.	questions.	LA 2.5
	TA 2.2	1422	Ciuca promot foodbook
	TA 2.3.	LA 2.3	Gives prompt leedback
	Describe a real	Apply semiconductor	TA 1.3
	application of	elements for	LA 1.3
	semiconductor	processing signals	
	elements usage for	(rectifying), for	Emphasizes time on task
	processing signals.	generating control	LA 2.3
		signals, for amplifying	
		and switch operations,	Respects diverse talents and ways of
		and to tackle common	learning
		issues.	LA 2.3
ILO3	TA 3.1	LA 3.1	Encourages contact between students
Implement drive	Present types of drives	Listen to the	and faculty
solutions with	for mechatronic	presentation,	LA 3.1
different electric	actuators: linear drives,	take notes, and ask	LA 3.2
drives on different	drives with wheels,	questions. Evaluate a	LA 3.3
platforms.	force-based drives.	variable frequency	TA 3.5
		drive (VFD) for control	LA 3.5
	TA 3.2	of an asynchronous	
	Present mechanical	electric motor).	Develops cooperation among students
	components of drives:	Students work in small	LA 3.1
	guides, axes, bearings,	groups.	LA 3.4
	couplings, sensors.	5	
		LA 3.2	Encourages active learning
	TA 3.3	Listen to the	LA 3.1
	Explain and show	presentation.	TA 3.3
	mathematical models	take notes and ask	TA 3.4
	of drive systems:	questions	1 A 3 4
	equations of motion	questions.	EA 3.4
	(displacement velocity	1422	Gives prompt foodback
	accoloration) friction	Liston to the	
	acceleration, metion.		
	TA 2 4	take notes and ask	TA 2 4
	Explain and show	auertions	
	proportion of drivery	questions.	
	properties of drives:	14.2.4	
	motion trajectory,	LA 3.4	LA 3.5
	absolute and relative	Apply and evaluate	Franksster time and t
	displacement, velocity	measurements of	Emphasizes time on task
	profiles, precision and	actuator displacement,	LA 3.1
	accuracy, torque	velocity and	LA 3.4
	matching.	acceleration. Apply and	
		evaluate different	

4





TA3.5 Encourage discussion on drive solutions for different applications and development platforms.Velocity profiles. Students work in small groups.Respects diverse talents and ways of LA3.1 LA3.4 LA3.4ILO 4TA4.1LA3.5 of testing drives in the laboratory and evaluate its properties.LA3.1 LA3.4ILO 4TA4.1LA4.1Encourages contact between students and facultyUse a mechatronic actuator in a closed-loopTA4.2Encourages contact between students and facultyUse a mechatronic actuator in a closed-loopTA4.2Usen to the presentation, take types of control (open- loop, closed-loop).Encourages active learning TA4.3TA4.3TA4.3Develops cooperation among students take. presentation, take take.Encourages active learning TA4.3TA4.3TA4.3Encourages active learning take. types of control (open- tesoritym, take notes, and ask questions.Encourages active learning TA4.3TA4.3Encourages active learning take.TA4.3TA4.4take.3TA4.3TA4.5popt and evaluate increments absolute encoder, and take.9TA4.4TA4.4take.9Emplainand show the control.TA4.5Describe and show the control.Emplain and show the control.TA4.5incremental and displatement and control.LA4.3TA4.4take.9LA4.3TA4.5LA4.4TA4.5Emplain and show the implementation of control.Emplaintens in small groups.<				
discussion on drive solutions for different applications and development platforms.Students work in small groups.learning LA 3.1 LA 3.1 LA 3.4104TA 4.1LA 5.5USe a mechatronic closed-loopTA 4.229 system.TA 4.2Describe and show the types of control (open- loop, closed-loop)LA 4.2TA 4.3LA 4.2Describe and show the types of control (open- loop, closed-loop)LA 4.2TA 4.3LA 4.2Describe and show the types of control (open- loop, closed-loop)LA 4.2TA 4.3LA 4.3Describe and show the types of control (open- control: potentiometer, resolver, encoder, tach-o generator.TA 4.3TA 4.4TA 4.3Describe and show the types of measurements control: potentiometer, resolver, encoder, tach-o generator.TA 4.3TA 4.4TA 4.3TA 4.4Encourages active learning tach-o generator.TA 4.4Explain and show the control algorithms with emphasis on PID control- algorithms with practical applications:TA 4.5Describe and show the control algorithms with practical applications:TA 4.5LA 4.4Listen to the implementation of control algorithms with practical applications:PIC mirrocontroller, Arduino microcontroller, Programming language.TA 4.5LA 4.4Listen to the implementation of control algorithms with practical applications:PIC mirrocontroller, Programming language.PIC mirrocontroller, <br< td=""><td></td><td>TA 3.5 Encourage</td><td>velocity profiles.</td><td>Respects diverse talents and ways of</td></br<>		TA 3.5 Encourage	velocity profiles.	Respects diverse talents and ways of
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applications and development platforms.LA 3.5 LS.25 LS.25 Discuss the experience of testing drives in the laboratory and evaluate its properties.LA 3.5 LA 3.5 LS.25 Discuss the experience of testing drives in the laboratory and evaluate its properties.LA 3.4 LA 3.5LUG 4 Use a mechatronic actuator in a closed-loop system.TA 4.1 Present the basics of linear control theory.LA 4.1 present the basics of linear control theory.Encourages contact between students and faculty LA 4.1 LA 4.2Use a mechatronic actuator in a closed-loop system.TA 4.2 Describe and show the types of measurements needed for closed-loop control: potentiometer, racho-generator.LA 4.2 LA 4.3 LA 4.3 TA 4.3 Describe and show the types of measurements resolver, encoder, tacho-generator.Encourages active learning TA 4.3 TA 4.3 TA 4.3 TA 4.3 TA 4.4TA 4.4 texpended for closed-loop control: potentiometer, racho-generator.LA 4.3 tacho-generator.TA 4.4 texplain and show the control algorithms with emphasis on PID control algorithms in practical applications: PIC microcontroller, Arduino microcontroller, Raspberry Pi micro computerLA 4.5TA 4.5 texplain and show the control algorithms in practical applications: PIC microcontroller, Arduino microcontroller, Raspberry Pi micro computerLA 4.4 LA 4.5TA 4.5 texplain and show the implementation of control algorithms in practical applications: PIC microcontroller, Arduino Microcontroller, Arduino Microcontroller, Arduino Microcontroller, Arduino Microcontroller, Arduino Microco		solutions for different	groups.	LA 3.1
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Course moment <sup>3</sup>	Weekday, date and time slot <sup>4</sup>	LA Type <sup>5</sup>	Location <sup>6</sup>	ILO Code	TLA Code <sup>7</sup>	Course material <sup>8</sup>	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	<u>SLIDES</u> <u>VIDEO</u>
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

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

<sup>&</sup>lt;sup>3</sup> 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.

<sup>&</sup>lt;sup>4</sup> It helps understanding relative positioning and duration of different course moments.

<sup>&</sup>lt;sup>5</sup> 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.

<sup>&</sup>lt;sup>6</sup> Class, home, lab, company

<sup>&</sup>lt;sup>7</sup> Follow the code of the previous template Table 2.1 (TA)

<sup>&</sup>lt;sup>8</sup> Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

<sup>6</sup> 





							Insulated-gate bipolar	
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 PVM characteristics Setting the PWM signal for a specific motor speed Application of the motor brake	<u>LINK</u>
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	<u>SLIDES</u>





							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 LA 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 generator 3- phase AC motor Delta or star circuits	<u>SLIDES</u> <u>VIDEO</u>
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 Properties of the asynchronous motor Mathematical model and linearisation Types of asynchronous motor control Variable frequency drive Synchronous AC motors	<u>SLIDES</u>
Class	Friday, 2 hours	Problem- solving tasks,	Presence	ILO 1	TA 1.1 TA 1.2 TA 1.3	Video lecture, slides	Synchronous motor Characteristics of the synchronous motor:	SLIDES VIDEO





					LA 1.2		Synchronous motor with variable frequency drive (VFD) Induction motor Characteristics of the induction motor: rotor speed, full load torque, slip Induction motor with direct-on-line drive (DOL) Induction Asynchronous motor with wound rotor Squirrel cage asynchronous motor Double squirrel cage	
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 1.4 LA 1.4 LA 3.1 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 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	<u>SLIDES</u> <u>VIDEO</u>
Laboratory	4 groups, 2 hours	Laboratory, Group work, Discussion	Presence, home	ILO 1	TA 1.2 TA 1.3 TA 1.4 LA 1.3	E-classroom laboratory setup description	DC stepper motors Analysing the data sheet: type, properties, dynamic characteristics	LINK





					LA 1.4 LA 3.4	and exercise instructions, report submission	AdaFruit MotorShield shield for the control of stepper motors Arduino Due microcontroller Arduino IDE and C++ Stepper motor operating modes: single, double, interleave and microstep operation Microstep: full step, 1/8 microstep, 1/16	
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	<u>SLIDES</u>
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	<u>SLIDES</u>
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	<u>SLIDES</u>
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	<u>SLIDES</u>





							PID control	
Class	Friday, 2 hours	Lecture	Presence	ILO 1	TA 1.1	Slides	Alternative drives for	SLIDES
					TA 1.2		mechatronic actuators	
					TA 1.3		Piezoelectric materials	
					TA 1.4		Piezoelectric motors	
					LA 1.1		Shape memory-based	
					LA 1.2		alloy actuators	
							Solenoids	

### 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.

Tuble 4: TAS JOT THE COURSE: I	Mechatronic Actuators, Parti	IET. UNILJ	
ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO1	Bloom level: 5	Bloom level: 6	
Compare pneumatic.			
hydraulic and electric	Type***: group work	Type***• Project	
actuators and select a	iffe igroup work	Type Troject	
actuators and select a	Shout description.	Chart description.	
	Muite a segret an	Short description.	
particular application in	write a report on	Design and build a	
terms of cost,	laboratory exercises on	mechatronic system that	
environmental conditions	different types of actuators.	contains a selected	
and operating conditions	The report includes	actuator.	
	measurements, answers to		
	the questions, evaluations		
	and discussions.		
ILO2	Bloom level: 5	Bloom level: 6	
Understand the role of			
different electronic	Type***: group work	Type***: Project	
semiconductor elements			
for mechatronic actuators	Short description:	Short description:	
and implement them.	Write a report on	Design and build a	
·	laboratory exercises on	mechatronic system that	
	different types of	uses semiconductor	
	semiconductor	components for various	
	components. The report	functionalities.	
	includes measurements.		
	answers to the questions.		
	evaluations and discussions.		
11.03	Bloom level: 5		
Implement drive solutions			
with different electric	Type***: group work		
drives on different	Type . group work		
nlatforms	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		
11.04	Ploom loval: E	Plaam laval: 6	
llee a machatronic actuator	Bioonnievel. 5	Bioonnievel. 6	
in a closed loop system		Ture***	
in a closed-loop system.	Type and group work	Type and Project	
	Short description:	Short description:	
	Write a report on	Design and build a	
	laboratory exercises on	mechatronic system that	
	different types of electric	functions as a closed-loop	
	motor closed-loop control	system.	
	The report includes		
	measurements, answers to		
		1	1

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





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 Concept/mind maps, interview, debate, problem sheet, minutes,
Comprehension	classify, discuss, present, rewrite	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,





### 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<sup>1</sup> 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

	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)

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

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





# 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<sup>2</sup>

### 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	TA 1.1	LA 1.1	Encourages contact between students
والمحمد المحمد المحمد الم	Present the role of	Listen to the presentation,	and faculty,
of the assombly	manufacturing	questions	
process within the	manufacturing.	questions.	LAI.2
manufacturing	TA1.2	LA 1.2	Gives prompt feedback,
domain and	Explain why	Listen to the presentation,	LA 1.3
discuss its	assembly process	take notes and ask	
importance	are important.	questions.	
		1412	
		Discuss the importance of	
		assembly process.	
ILO2	TA2.1	LA 2.1	Encourages contact between students
	Explain	Listen to the presentation,	and faculty
create	mathematical and	take notes, and ask	LA 2.1
mathematical and	feature models of	questions.	LA 2.2
feature models of	assemblies in the		
assemblies and use	context of design		Encourages active learning
them in context of	and evaluation of		LA 2.2
design and	assembly systems.		Ciuca meanat foodbook
evaluation of	TA2.2	14.2.2	Gives prompt reedback,
assembly systems	Describe and show	LA 2.2	LA 2.2
	instructions for the	Apply and evaluate	Bechaete diverse talents and wave of
	project	appropriate models.	learning
	project	1	learning

<sup>2</sup> 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





			ΤΛ 2 2
11.03	ΤΛ3 1	1431	Encourages contact between students
	Explain dynamic and	LA 3.1	and faculty
account for the	static constraints of	take notes and ask	
dynamic and static	assembly process	questions	
constraints of a	assembly process	questions.	LA 3.2
manual or	TA3 2	1432	Encourages active learning
automatic	Describe and show	Exaluate the constraints of	
accomply process	instructions for the	assembly process	LA 3.2
assembly process	nroiect	assembly process.	Gives prompt feedback
	project		
			Respects diverse talents and ways of
			learning
			TA 3.2
			LA 3.2
ILO4	TA 4.1	LA 4.1	Encourages contact between students
	Explain assembly	Listen to the presentation,	and faculty
analyse a given	sequences.	take notes, and ask	LA 4.1
product and define		questions.	LA 4.2
feasible assembly			
sequences	TA 4.2	LA 4.2	Encourages active learning
	Describe and show	Evaluate and define	LA 4.2
	instructions for the	feasible assembly	
	project	sequence.	Gives prompt feedback,
			LA 4.2
			Respects diverse talents and ways of
			learning
			TA 4.2
			LA 4.2
ILO5	TA 5.1	LA 5.1	Encourages contact between students
	Explain technical	Listen to the presentation,	and faculty
choose the best	and economic	take notes, and ask	LA 5.1
sequence by	criteria for assembly	questions.	LA 5.2
applying technical	sequences.		
and economic			Encourages active learning
criteria		LA 5.2	LA 5.2
	TA 5.2	Evaluate and choose the	
	Describe and show	best assembly sequence	Gives prompt feedback,
	instructions for the	using technical and	LA 4.2
	project	economic criteria.	
			Respects diverse talents and ways of
			learning
			TA 5.2
			LA 5.2
ILO6	TA 6.1	LA 6.1	Encourages contact between students
	Present the function	Listen to the presentation,	and faculty,
describe the	of elements of	take notes, and ask	LA 6.1
function of all the	automatic and	questions.	
elements of an	manual assembly		
assembly system	system.		
(both automatic			
and manual)			
ILO7	TA 7.1	LA 7.1	Encourages contact between students
			and faculty





avaluate the	Evalaia DEA	Liston to the presentation	1471
evaluate the		Listen to the presentation,	
Impact of the	methodologies.	take notes, and ask	LA 7.2
product design on		questions.	
the assembly			Encourages active learning
process, by			LA 7.2
applying the	TA 7.2	LA 7.2	
Boothroyd DFA	Describe and show	Apply DFA methodologies	Gives prompt feedback,
methodologies	instructions for the	to given product.	LA 7.2
	project		
			Respects diverse talents and ways of
			learning
			TA 7.2
			LA 7.2
ILO8	TA 8.1	LA 8.1	Encourages contact between students
	Explain design	Listen to the presentation,	and faculty
identify the	requirements of	take notes, and ask	LA 8.1
requirements on	assembly station.	questions.	LA 8.2
design of an			
assembly station			Encourages active learning
and provide			LA 8.2
instructions for the	TA 8.2	LA 8.2	
subsequent	Describe and show	Discuss and explain the	Gives prompt feedback,
implementation	instructions for the	design requirements for	LA 8.2
	project	assembly station	
	[···]	implementation	Respects diverse talents and ways of
			learning
11.09	ΤΔ 9 1	1491	Encourages contact between students
	Explain costs	Liston to the presentation	and faculty
calculate the costs	evaluation and	take notes, and ask	
calculate the costs		take notes, and ask	
important	manual and	questions.	LA 9.2
economical key	automatic assembly		Encourages active learning
performance	systems.		LA 9.2
indicators (KPIs)			
for standard			Gives prompt feedback,
assembly systems			LA 9.2
(poth manual and	1A 9.2	LA 9.2	
automatic)	Describe and show	Use costs evaluation and	Respects diverse talents and ways of
	instructions for the	KPIs for manual and	learning
	project	automatic assembly.	TA 9.2
			LA 9.2

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





Course moment <sup>3</sup>	Weekday, date and time slot <sup>4</sup>	LA Type⁵	Location <sup>6</sup>	ILO Code	TLA Code <sup>7</sup>	Course material <sup>8</sup>	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

<sup>3</sup> 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.

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

<sup>6</sup> Class, home, lab, company

<sup>7</sup> Follow the code of the previous template Table 2.1 (TA)

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

<sup>&</sup>lt;sup>4</sup> It helps understanding relative positioning and duration of different course moments.





							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 TA7.1 TA7.2 TA8.1 TA8.2 TA9.1 TA9.2	-	Product description Bill of material Assembly feature Liaison diagram Precedence diagram Design for assembly Manual assembly Line balancing Workstation design Economic analysis Assembly systems	-

### Table 3: Learning activities examples (column 3)

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





### Assessment Task

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

Link to material

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

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





	choose the best sequence	Type***: Project		
	by applying technical and	Short description: Applyso		
		the given product and		
		define the best assembly		
		sequence applying technical		
		and economic criteria.		
Ì	ILO6	Bloom level: 2		
	describe the function of all	Type***: Exam question		
	the elements of an			
	assembly system (both	Short description: Answer		
	automatic and manual)	questions on function of all		
		elements in assembly		
		system.		
ł	11.07	Bloom level: 5		
	1207	biodin level. 5		
	evaluate the impact of the	Type***: Project		
	product design on the	.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
	assembly process, by	Short description: Analyse		
	applying the Boothroyd	the given product and		
	DFA methodologies	assess its design applying		
		the DFA method.		
	ILO8	Bloom level: 2		
	identify the requirements	Type***: Project		
	on design of an assembly	Type . Project		
	station and provide	Short description: Analyse		
	instructions for the	the given product and		
	subsequent	define its requirements on		
	implementation	design of an assembly		
		station.		
	ILO9	Bloom level: 3		
	calculate the costs and the	Type***: ***: Project		
	most important economical	Chart description Analyse		
	(KPIs) for standard	the given product and		
	assembly systems (both	calculate its costs and KDIs		
	manual and automatic)			
l	manaal and automatic)		l	

# Table 5: AT examples

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





# Intended Learning Outcomes (ILOs)

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

- **Short description**: ILOs has in general from 150 to 250 characters.
- **Bloom Verb Level**: detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy<sup>1</sup> 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

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

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

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





ILO4	apply proper inventory control methods for a product with known demand	Level_3	proper inventory control methods	a product with known demand
			(inventory, control, type of inventory, ABC analysis, EOO model.	(product, demand)
			quantity discount model)	
ILO5	choose the best operations scheduling approach to optimize certain shop floor performance indicators	Level_5	the best operations scheduling approach	optimize certain shop floor performance indicators
			sequencing rules, line balancing)	(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	Level_2 Level_3	appropriate lean tools	continuously improve shop floor performance
	continuousiy improve shop floor performance		(lean philosophy, tools, 55, Toyota production system, wates, value stream mapping, PDCA,	(continuous improvement, performance)
ILO8	apply value stream mapping for current and future states	Level_3	value stream mapping for current and future	a given case study
	to a given case study		states	(case study)
			(value stream mapping, current state, future state, action plan, lead time, capacity analysis,	
			continuous flow, factory layout, product families, heijunka)	

# 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<sup>2</sup>

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

<sup>2</sup> 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

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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	TA 4.1 Explain inventory control methods. TA 4.2	LA 4.1 Listen to the presentation, take notes, and ask questions. LA 4.2	Encourages contact between students and faculty LA 4.1 LA 4.2 Encourages active learning
known demand	Describe and show Examples during tutorial class	Apply and use the inventory control methods in the given exercises.	LA 4.2 Gives prompt feedback, LA 4.2 Respects diverse talents and ways of learning TA 4.2
ILO5 choose the best operations scheduling	TA 5.1 Explain operations scheduling approaches.	LA 5.1 Listen to the presentation, take notes, and ask questions.	Encourages contact between students and faculty LA 5.1 LA 5.2
approach to optimize certain shop floor performance indicators	TA 5.2 Describe and show Examples during tutorial class	LA 5.2 Evaluate and select the best operations scheduling approach for optimizing production performance indicators.	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	TA 7.1 Explain lean principles and tools.	LA 7.1 Listen to the presentation, take notes, and ask questions.	Encourages contact between students and faculty LA 7.1 LA 7.2
continuously improve shop floor performance	TA 7.2 Describe and show instructions for lean laboratory sessions	LA 7.2 Explain, discuss and apply appropriate lean tools during the lean laboratory sessions.	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	TA 8.1	LA 8.1	Encourages contact between students
	Explain value	Listen to the presentation,	and faculty
apply value stream	stream mapping	take notes, and ask	LA 8.1
mapping for	tool.	questions.	LA 8.2
current and future			
states to a given			Encourages active learning
case study			LA 8.2
	TA 8.2	LA 8.2	
	Describe and show	Discuss, explain and use	Gives prompt feedback,
	instructions for the	the value stream mapping	LA 8.2
	project	for a given case study.	
			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 <sup>3</sup>	Weekday, date and time slot <sup>4</sup>	LA Type⁵	Location <sup>6</sup>	ILO Code	TLA Code <sup>7</sup>	Course material <sup>8</sup>	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

<sup>3</sup> 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.

<sup>5</sup> 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.

<sup>6</sup> Class, home, lab, company

<sup>7</sup> Follow the code of the previous template Table 2.1 (TA)

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

<sup>&</sup>lt;sup>4</sup> It helps understanding relative positioning and duration of different course moments.





							loyota production system, wates, value stream mapping, PDCA, SMED, Kapbap	
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, 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	<u>link</u> link
Laboratory	3 hours	Laboratory	IRL	ILO2 ILO ILO7	TA2.2 TA7.2	Slides	Kanban inventory, control, type of inventory, ABC analysis, EOQ model, order point	link
Laboratory	4 hours	Laboratory	IRL	ILO7	TA7.2	-	lean philosophy, tools, 5S, Toyota production system, wates, value stream mapping, PDCA, SMED, Kanban	-
Class	2 hours	Lecture	IRL	ILO5	TA5.1	slides	scheduling, operations, sequencing rules, line balancing KPI	link
Tutorial	2 hours	Tutorial	IRL	ILO5	TA5.2	slides	scheduling, operations, sequencing rules, line balancing KPI	link





### Table 3: Learning activities examples (column 3)

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

### **Assessment Task**

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

### Link to material

Tuble 4. Ars jor the course. I	fulling and control, i artifici		
ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
ILO1	Bloom level: 2		
explain fundamental principles used in	<b>Type***:</b> Exam questions		
traditional production planning and control	Short description: Answer questions related to the		
systems	fundamental principles of production planning and		
	control.		
ILO2	Bloom level: 6		

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





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





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

# Table 5: AT examples

Bloom Taxonomy	EGV	Assessment Task (Examples)
Remember	arrange, define, list, identify	Multiple choice, quiz/test, question banks, take-home examinations Concept/mind maps, interview, debate, problem sheet, minutes,
Comprehension	classify, discuss, present, rewrite	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,





# **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<sup>1</sup> 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)
  - $\circ~$  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

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

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





		1		
	applying principles of		various metal forming	
	deformation and friction		processes	
	analysis, and selecting			
	appropriate equipment for		(extrusion and rolling	
	operations like forging and		techniques, principles of	
	sheet metal processing.		deformation and friction	
			analysis, equipment)	
ILO	Apply and use metrology	Level_3	Metrology, quality and,	Metrology and inspection
4	concepts such as tolerance,		cost principles of various	operations
	geometric errors, surface		inspection processes	
	texture, precise instruments			
	(calipers, micrometers), and		(tolerance, geometric	
	CMMs for accurate		errors, surface texture,	
	inspections, and program		precise instruments	
	measurements effectively		(calipers, micrometers),	
			and CMMs)	
ILO	Analyze and evaluate joining	Level_3	manufacturing, quality	Joining operations
5	techniques in manufacturing		and, cost principles of	
	such as welding (gas, arc,		various joining processes	
	resistance, brazing, plasma)			
	and related defects		(welding (gas, arc,	
			resistance, brazing,	
			plasma) and related	
			defects)	





# 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<sup>2</sup>

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

ILO reference (Highlight the Verb that need be	Teaching Activity (What the teachers do)	Learning Activity (What the students do)	How does this use the 7 Principles of good learning
aligned)	,		
ILO 1	TA 1.1	LA 1.1	Encourages contact between students
Evaluate advanced	Present machining	Listen to the presentation,	and faculty,
machining	processes in	take notes, and ask	LA 1.1
their quality	manufacturing	questions.	LAI.2
productivity and	TA 1 2	1412	Encourages active learning
costs in	Explain how chip	Listen to the presentation.	TA 1.3
manufacturing	removal technology	take notes and ask	TA 1.4
environments and	can be applied for	questions.	LA 1.3
operations	manufacturing a		LA 1.4
	part		
		LA 1.3	Gives prompt feedback,
		Apply and evaluate chip	TA 1.4
	TA 1.3	removal principles on the	LA 1.3
	Describe and show a	project case.	LA 1.4
	real application of		
	machining	LA 1.4	Respects diverse talents and ways of
	processes for	Discuss about the	learning
	manufacturing a	experience on the	IA 1.3
	part and	application provided.	LA 1.3
	nstructions for the		
	project case		
	TA 1.4		
	Encourage		
	discussion on the		
	application		
	provided.		

<sup>2</sup> 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

3

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ILO2	TA 2.1	LA 2.1	Encourages contact between students
Design and	Present casting and	Listen to the presentation,	and faculty,
optimize casting	solidification	take notes, and ask	LA 2.1
processes	processes	questions.	LA2.2
considering model			
and core design,	TA 2.2	LA 2.2	Encourages active learning
gating system,	Explain how casting	Listen to the presentation,	TA 2.3
cooling modules,	process technology	take notes and ask	TA 2.4
and material	can be applied for	questions.	LA 2.3
properties.	manufacturing a		LA 2.4
Evaluate economic	part	14.2.2	
reasibility, identify		LA 2.3	Gives prompt feedback,
and rectify	TA 2 2	Apply and evaluate casting	
defects and apply	TA 2.5	and solidilication	
Design for	real application of	principles on the project	LA 2.4
Manufacturing	casting processes	Case.	Respects diverse talents and ways of
nrincinles	for manufacturing a	1424	learning
principies.	nart and	Discuss about the	
	instructions for the	experience on the	IA 2.3
	virtual simulation	application provided.	
	using FEM software		
	TA 2.4		
	Encourage		
	discussion on the		
	application		
	provided.		
ILO3	TA 3.1	LA 3.1	Encourages contact between students
Evaluate metal	Present metal	Listen to the presentation,	and faculty,
forming processes	forming processes	take notes, and ask	
and rolling	тара	questions.	
tochniquos	Fynlain how motal	1422	
applying principles	forming process	LA 3.2	TA 3.2
of deformation	technology can be	take notes and ask	Encourages active learning
and friction	applied for	questions	
analysis and	manufacturing a	questions.	EN3.5
selecting	part		Gives prompt feedback.
appropriate	<b>1</b>	LA 3.3	LA 3.3
equipment for		Apply and evaluate metal	
operations like		forming principles	Respects diverse talents and ways of
forging and sheet			learning
metal processing.			LA 3.3
ILO 4	TA 4.1	LA 4.1	Encourages contact between students
Apply and use	Present metrology	Listen to the presentation,	and faculty,
metrology	principles	take notes, and ask	LA 4.1
concepts such as		questions.	LA4.2
tolerance,	TA 4.2		
geometric errors,	Explain how	LA 4.2	Encourages active learning
surface texture,			TA 4.2
	metrology	Listen to the presentation,	TA 4.3
precise	metrology technology can be	Listen to the presentation, take notes and ask	LA 4.3
precise instruments	metrology technology can be applied for	Listen to the presentation, take notes and ask questions.	LA 4.3
precise instruments (calipers,	metrology technology can be applied for inspecting a part	Listen to the presentation, take notes and ask questions.	IA 4.3 LA 4.3 Gives prompt feedback,
precise instruments (calipers, micrometers), and	metrology technology can be applied for inspecting a part	Listen to the presentation, take notes and ask questions.	Gives prompt feedback, LA 4.3





inspections, and program measurements effectively	Describe and show a real application of casting processes for manufacturing a part and	Apply and evaluate metrology principles	Respects diverse talents and ways of learning TA 4.3 LA 4.3
	instructions for the		
	project		
	TA 5 4		E
ILUS Anglung and	TA 5.1		Encourages contact between students
Analyze and	Present joining	Listen to the presentation,	and faculty,
evaluate joining	techniques and	take notes, and ask	LA 5.1
techniques in	principles	questions.	TA 5.1
manufacturing			LA5.2
such as welding	TA 5.2	LA 5.2	TA 5.2
(gas, arc,	Explain how joining	Listen to the presentation,	
resistance, brazing,	technology can be	take notes and ask	Encourages active learning
plasma) and	applied for	questions.	LA 5.3
related defects	assemble multiple		
	components		Gives prompt feedback,
		LA 5.3	LA 5.3
		evaluate joining principles	
			Respects diverse talents and ways of
			learning
			LA 5.3
manufacturing such as welding (gas, arc, resistance, brazing, plasma) and related defects	TA 5.2 Explain how joining technology can be applied for assemble multiple components	LA 5.2 Listen to the presentation, take notes and ask questions. LA 5.3 evaluate joining principles	LA 5.2 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 <sup>3</sup>	Weekday, date and time slot <sup>4</sup>	LA Type⁵	Location <sup>6</sup>	ILO Code	TLA Code <sup>7</sup>	Course material <sup>8</sup>	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. <u>link</u> 2. <u>link</u>

<sup>3</sup> 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.

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

<sup>6</sup> Class, home, lab, company

<sup>7</sup> Follow the code of the previous template Table 2.1 (TA)

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

<sup>&</sup>lt;sup>4</sup> It helps understanding relative positioning and duration of different course moments.





					LA1.1., LA1.2		Cutting Force Cutting Insert Types of Chips Cutting Fluids Tool Insert	
Class, Homewor	1 hour	Discussion, Laboratory	Presence and Home	ILO1	TA1.2 TA1.3	www page	Orthogonal Cutting Chip Formation Cutting Ratio	link
					LA1.2 LA1.3		Cutting Force Cutting Insert Types of Chips Cutting Fluids Tool Insert	
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2	Video lecture	Oblique Cutting Cutting Parameters Cutting Edge Angles Machining Parameters	link
					LA1.2		Measurement Units Surface Roughness Feed per Revolution Corner Radius Registration Angles	
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2	Video lecture	Cutting Energy Cutting Power	link
					LA1.1., LA1.2		Kronenberg's Cutting Force Specific Cutting Energy Single Point Tool Geometry Standardized Tool Angles Main Views and Sections Cutting Angles	
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2	Video lecture	Clearance Angles Psi Cutting Edge	link
					LA1.1., LA1.2		Lambda Cutting Edge Minimum Uncut Chip Thickness Plowing Chip Breakage Diagram	
Class	2 hours	Lesture	Dressnes		TA1 1	Video	Tool Damage Morphology Tool Wear	link
Class	2 nours	Lecture	and Virtual		TA1.1, TA1.2	lecture	ISO Coding Tool Materials CBN (Cubic Boron Nitride)	
					LA1.2		PVD (Physical Vapor Deposition) CVD (Chemical Vapor Deposition)	
							Tool Damage Morphology Tool Wear Evaluation Parameters	
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2	Video lecture	Taylor's Law Cost Estimation Active and Idle Times	link
					LA1.1., LA1.2		Setup Times Organizational Methods for Efficiency	
							Optimization Economic and Productive Speeds	
							Turning Operations Cylindrical Turning Facing Threading	
Homewor	k 3-5 hours	Reading	home	ILO1	TA1.1,	Chapter	Taylor's Law	1. link
		materia					Active and Idle Times	<u>2. mik</u>
					LA1.2		Organizational Methods for Efficiency	
6								





Class	2 hours	Lecture	Presence	ILO1	TA1.1,	Video	Cost and Time Optimization Economic and Productive Speeds Turning Operations Cylindrical Turning Facing Threading Machining Tolerances	link
			and Virtual		TA1.2 LA1.1., LA1.2	lecture	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	
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. <u>link</u> 2. <u>link</u>
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. <u>link</u> 2. <u>link</u> 3. <u>link</u>
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	link
7	<u> </u>	1	1	1		l	iviecnanical Components	





							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. <u>link</u> 2. <u>link</u> 3. <u>link</u> 4. <u>link</u> 5. <u>link</u> 6. <u>link</u>
Class	2 hours	Lecture, Discussion	Presence and Virtual		TA1.3, TA1.4 LA1.3., LA1.4	Video lecture	Cycle Definition Drawing Preliminary Analysis Surface Definition Manufacturing Process Selection Phases and Subphases Breakdown Alternative Cycle Analysis Process Planning Surface Analysis Preliminary Drawing Evaluation Phase Division	link
Class	2 hours	Lecture, Discussion	Presence and Virtual	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Video lecture	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	link
Class	2 hours	Lecture, Discussion	Presence and Virtual	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Video lecture	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	link
Homework	minutes	Reflection	Home	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Videos	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	link
Homework	2-5 hours	Reading material	Home	ILO1	TA1.3, TA1.4 LA1.3., LA1.4	Chapter	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	link
Homework	2-5 hours	Create a new report, group work	Home	ILO1	TA1.3, TA1.4	Peer work	Operation Sequence Selection	link





					LA1.3., LA1.4		Economic, Dimensional, and Technological Priority Criteria Tool Selection in Turning Cutting Parameter Selection	
Class	2 hours	Lecture	Presence and Virtual	ILO1	TA1.1, TA1.2 LA1.1, LA1.2	Video lecture	Milling Force and Power Estimation Interrupted Cutting Ball Screw Threads Equipment Comparison Boring Head vs. Reamer vs. Boring Machine Straight-line Machining Broaching Grinding Machine Configuration	link
Homework	minutes	Reflection	Home	ILO1	TA1.1, TA1.2 LA1.1, LA1.2	Videos	Milling Force and Power Estimation Interrupted Cutting Ball Screw Threads Equipment Comparison Boring Head vs. Reamer vs. Boring Machine Straight-line Machining Broaching Grinding Machine Configuration	1. <u>link</u> 2. <u>link</u> 3. <u>link</u> 4. <u>link</u>
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. <u>link</u> 2. <u>link</u>
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	Bind Risers Influence Radius Sizing and Attachment Collar End Effect and Chillers Directional Solidification	1. <u>iink</u> 2. <u>link</u> 3. <u>link</u>
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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 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. <u>link</u> 2. <u>link</u>





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 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. <u>link</u> 2. <u>link</u> 3. <u>link</u> 4. <u>link</u> 5. <u>link</u>





							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. <u>link</u> 2. <u>link</u> 3. <u>link</u>
Class	2 hours	Lecture	Presence and Virtual	ILO4	TA4.1, TA4.2 LA4.1., LA4.2	Video lecture	Tolerances Macrogeometric Errors Instrument Calibration Certification Statistical Process Control Measurement Tools Microgeometric Measurements Form Errors Surface Texture Roughness Measurement Roughness Tester Profile Sampling Filtering Roughness Parameters Coordinate Measuring Machine (CMM)	link
Homework	2-5 hours	Create a new report, group work	Home	ILO4	TA4.1, TA4.2 LA4.2., LA4.3	Peer work	Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria Inspection process selection Inspection tool	link
Homework	minutes	Reflection	Home	ILO4	TA4.1, TA4.2 LA4.1., LA4.2	Videos	Tolerances Macrogeometric Errors Instrument Calibration Certification Statistical Process Control Measurement Tools Microgeometric Measurements Form Errors Surface Texture Roughness Measurement Roughness Tester Profile Sampling Filtering Roughness Parameters Coordinate Measuring Machine (CMM) Operation Sequence Selection Economic, Dimensional, and Technological Priority Criteria	link





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

# Table 3: Learning activities examples (column 3)

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





# Assessment Task

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

 Material:
 https://drive.google.com/drive/folders/0Bys-IU\_Yv0e\_RWIRd1BzTmRoZ0k?resourcekey=0 

 WKX\_zipVKBurMEnu6ynEVg&usp=sharing

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

ILO reference (Highlight the Verb)	Assessment task 1	Assessment task 2	Assessment task n
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<sup>1</sup> 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	Level_2	Modern information	decision support
	technologies, such as OLAP,		technologies	processes
	data warehouses, data mining			
	methods , artificial		(OLAP, data warehouse,	
	intelligence methods		data mining, artificial	
			intelligence, manage-	
			ment desktop)	
ILO2	Implement an example	Level_3	management desktop	Data visualization
	management desktop			
			(management desktop,	
			data visualization, Excel,	
			pivot tables)	

<sup>&</sup>lt;sup>1</sup> For more info refer to: <u>https://doi.org/10.3390/educsci12070438</u>.





# 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<sup>2</sup>

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

<sup>2</sup> 7 principles of good learning:

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

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





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

Course	Weekday, date	LA Type⁵	Location <sup>6</sup>	ILO	TLA	Course	Keywords	Link to the
moment <sup>3</sup>	and time slot <sup>4</sup>			Code	Code <sup>7</sup>	material <sup>8</sup>		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. <u>dashboard introduction.pptx</u>
- 3. Files required to complete the dashboard workshop:
  - a. <u>dashboard template.xlsx</u>
    - b. <u>customers.xlsx</u>
    - c. continents.xlsx
    - d. <u>orders.xlsx</u>
  - e. products.xlsx
- 4. Dashboard workshop results: <u>dashboard result of the classes.xlsx</u>

<sup>&</sup>lt;sup>3</sup> 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.

<sup>&</sup>lt;sup>4</sup> It helps understanding relative positioning and duration of different course moments.

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

<sup>&</sup>lt;sup>6</sup> Class, home, lab, company

<sup>&</sup>lt;sup>7</sup> Follow the code of the previous template Table 2.1 (TA)

<sup>&</sup>lt;sup>8</sup> Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

<sup>3</sup> 





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





### Table 5: AT examples

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




## Intended Learning Outcomes (ILOs)

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

- **Short description**: ILOs has in general from 150 to 250 characters.
- **Bloom Verb Level**: detailing the action expected and referring to the expected level of understanding as expressed in the well-known Bloom taxonomy<sup>1</sup> 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

	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)

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

<sup>&</sup>lt;sup>1</sup> For more info refer to: <u>https://doi.org/10.3390/educsci12070438</u>.





## 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<sup>2</sup>

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	Encourages contact between students and faculty, LA 1.1 LA1.2 Gives prompt feedback, LA 1.3
		related to modelling continuous-time systems .	
ILO2 Construct a simulation model reflecting the key features and behaviour of the system under	TA2.1 Describe and present the modelling process using system dynamics.	LA 2.1 Observe the presentation, take notes, and ask questions.	Encourages contact between students and faculty LA 2.1 LA 2.2
analysis	TA2.2 Show and explain model formulation for manufacturing and management systems.	LA 2.2 Implement and discuss appropriate models.	Encourages active learning Gives prompt feedback, Develops reciprocity and cooperation among students LA 2.2

<sup>2</sup> 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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ILO3 Analyse simulation experiment results for continuous- time systems	TA3.1 Show and explain simulation experiments and result analysis for manufacturing and management systems.	LA 3.1 Observe the presentation, take notes, and ask questions.	Encourages contact between students and faculty' Gives prompt feedback, LA 3.1 LA 3.2
	TA3.2 Show and explain assumptions of the results analysis	LA 3.2 Interpret the results. Identify decision variables and constraints. Suggest and justify opportunities for model improvement.	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	Weekday, date	LA Type⁵	Location <sup>6</sup>	ILO	TLA	Course	Keywords	Link to the
moment <sup>3</sup>	and time slot <sup>4</sup>			Code	Code <sup>7</sup>	material <sup>8</sup>		material
Class	2 hours	Lecture	Class	ILO1	TA1.1	slides	Introduction	Intro-System
							Systems thinking	dynamics.pptx
							System dynamics	
							method	
							Causal dependencies	
							Feedback loop	
Class	2 hours	Lecture	Class	ILO1	TA1.2	slides	Continuous-time	Modeling-System
							system	dynamics.pptx
							System archetypes	
							Modelling process	
							Mental and structural	
							models	
Class	2 hours	Lecture	Class	ILO2	TA2.1	chapter	Vensim PLE	System dynamics
							presentation	main concepts.pdf
							Model settings	
							Mathematical model	
							notation	
							Stocks and flows	
							Material and	
							information flow	
Class	4 hours	Tutorial	Class	ILO2	TA2.2	Slides,	Manufacturing system	System dynamics in
						chapter	components	manufacturing.pptx
							Production flow	Models of the
							Line balancing	manufacturing
							Flow discretization	system
							Assembly process	components.pdf
							Enterprise in the	
							market environment	
							KISK factors	

<sup>&</sup>lt;sup>3</sup> 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.

<sup>&</sup>lt;sup>4</sup> It helps understanding relative positioning and duration of different course moments.

 $<sup>^{\</sup>rm 5}$  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. <sup>6</sup> Class, home, lab, company

<sup>&</sup>lt;sup>7</sup> Follow the code of the previous template Table 2.1 (TA)

<sup>&</sup>lt;sup>8</sup> Material supporting each course moment. Can be: 3d models, www page, note, quizz, code, video lecture, book, chapter, task, video, slides, peer work

<sup>3</sup> 





Class	2 hours	Tutorial	Class	ILO3	TA3.1	Open access article	Setting up simulation parameters, Simulation experiment observation Collecting simulation results Quantitative and qualitative application	Problems of System Dynamics model development for complex product manufacturing process.pdf
Class	2 hours	Tutorial	Class	ILO3	TA3.2	Chapter	Simulative analysis 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.

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 <u>Simulation modelling -</u> <u>assesment test.pdf</u> 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.		

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

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# 7. References

- [1] A. Maffei, E. Boffa, F. Lupi, M. Lanzetta, On the Design of Constructively Aligned Educational Unit, Educ Sci (Basel). 12 (2022) 438. https://doi.org/10.3390/educsci12070438.
- [2] A. Maffei, M. Giudici, K. Samir, An ontological framework to support the creation and use of phenomenograpical knowledge, EDUNINE 2019 - 3rd IEEE World Engineering Education Conference: Modern Educational Paradigms for Computer and Engineering Career, Proceedings. (2019). https://doi.org/10.1109/EDUNINE.2019.8875801.
- J. Biggs, Enhancing teaching through constructive alignment, High Educ (Dordr). 32 (1996)
   347–364. https://doi.org/10.1007/BF00138871/METRICS.
- [4] Bloom: Taxonomy of Educational Objectives: Handbook II Google Académico, (n.d.). https://scholar.google.com/scholar\_lookup?title=Taxonomy+of+Educational+Objectives:+Ha ndbook+I:+Cognitive+Domain&author=Bloom,+B.S.&author=Englehart,+M.D.&author=Furst, +E.J.&author=Hill,+W.H.&author=Krathwohl,+D.R.&publication\_year=1956 (accessed November 27, 2023).
- [5] E. Boffa, F. Lupi, M. Lanzetta, A. Maffei, The Digitalization of Engineering Curricula: Defining the Categories that Preserve Constructive Alignment, Communications in Computer and Information Science. 1542 CCIS (2022) 333–346. https://doi.org/10.1007/978-3-030-96060-5\_24/COVER.
- [6] F. Lupi, M.M. Mabkhot, M. Finžgar, P. Minetola, D. Stadnicka, A. Maffei, P. Litwin, E. Boffa, P. Ferreira, P. Podržaj, R. Chelli, N. Lohse, M. Lanzetta, Toward a sustainable educational engineer archetype through Industry 4.0, Comput Ind. 134 (2022) 103543. https://doi.org/10.1016/J.COMPIND.2021.103543.
- T. Anderson, D.W.-J. of interactive M. in, undefined 2004, The educational semantic web: Visioning and practicing the future of education, Auspace.Athabascau.CaT Anderson, D
   WhitelockJournal of Interactive Media in Education, 2004•auspace.Athabascau.Ca. (n.d.).
   https://auspace.athabascau.ca/bitstream/handle/2149/724/the\_educatoinal\_semantic\_web.
   pdf?se (accessed November 20, 2023).
- [8] C. Guangzuo, C. Fei, L. Shufang, OntoEdu: Ontology-based Education Grid System for e-Learning, (n.d.).
- [9] G. Acampora, V. Loia, M. Gaeta, Exploring e-learning knowledge through ontological memetic agents, IEEE Comput Intell Mag. 5 (2010) 66–77. https://doi.org/10.1109/MCI.2010.936306.

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- [10] D. Mouromtsev, F. Kozlov, ... O.P.-... E. and the, undefined 2013, Development of an ontologybased e-learning system, SpringerD Mouromtsev, F Kozlov, O Parkhimovich, M ZeleninaKnowledge Engineering and the Semantic Web: 4th International Conference, KESW, 2013•Springer. 394 (2013) 273–280. https://doi.org/10.1007/978-3-642-41360-5\_23.
- [11] V. Vasiliev, F. Kozlov, D. Mouromtsev, S. Stafeev, O. Parkhimovich, ECOLE: An ontology-based open online course platform, Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). 9500 (2016) 41–66. https://doi.org/10.1007/978-3-319-30493-9\_3/TABLES/4.
- G. Fokou Pelap, C. Faron Zucker, F. Gandon, L. Polese, Web Semantic Technologies in Web
   Based Educational System Integration, Lecture Notes in Business Information Processing. 372
   LNBIP (2019) 170–194. https://doi.org/10.1007/978-3-030-35330-8\_9/FIGURES/13.
- [13] N.N.W. Tay, S.C. Yang, C.S. Lee, N. Kubota, Ontology-based adaptive e-textbook platform for student and machine co-learning, IEEE International Conference on Fuzzy Systems. 2018-July (2018). https://doi.org/10.1109/FUZZ-IEEE.2018.8491480.
- [14] E. Ilkou, H. Abu-Rasheed, M. Tavakoli, S. Hakimov, G. Kismihók, S. Auer, W. Nejdl, EduCOR: An Educational and Career-Oriented Recommendation Ontology, Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). 12922 LNCS (2021) 546–562. https://doi.org/10.1007/978-3-030-88361-4\_32/TABLES/2.
- [15] A. Maffei, L. Daghini, A. Archenti, N. Lohse, CONALI Ontology. A Framework for Design and Evaluation of Constructively Aligned Courses in Higher Education: Putting in Focus the Educational Goal Verbs, Procedia CIRP. 50 (2016) 765–772. https://doi.org/10.1016/J.PROCIR.2016.06.004.
- [16] A. Maffei, E. Boffa, C. Nuur, An Ontological Framework for the Analysis of Constructively Aligned Educational Units, Lecture Notes in Mechanical Engineering. (2019) 185–193. https://doi.org/10.1007/978-3-030-17269-5\_13/COVER.







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