IoToAI

FROM INTERNET OF THINGS
TO ARTIFICIAL INTELLIGENCE

(A VET FOR BUSINESS IN THE DIGITAL ERA)

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Teaching Handbook for blended learning, digital strategies and implementation subjects

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1. Introduction

This toolkit[1] is a teaching handbook guide for Vocational Educational Training (VET) providers and teachers in designing and implementing blended-learning approaches. It summarizes the process a VET provider or teacher should follow when is moving its training programme to a blended model, where some elements are delivered in a face to face (f2f) setting and others in online mode.

This toolkit has been designed as an exemplary guideline for digitalization subjects that includes technology enhanced research-based educational aids and resources to support the development of students' digital leadership, focused on novel and disruptive Information and Communication Technologies (ICT), such as Internet of Things (IoT), Cloud Computing, Artificial Intelligence (AI) and Big Data skills, among others.

Out of the Introduction, this handbook is organized in seven main sections:

Section 2, where the handbook presents the Conceptual framework for developing toolkits for blended Learning of IoToAI topics in VET. The goal of this contribution is to develop the conceptual framework, from the technological and pedagogical knowledge necessary to effectively integrate IoT, Cloud, AI, Big Data, etc., within the different curricular subjects, developed in the framework of the European project IoToAI[2]. The conceptual framework is based on research knowledge about student cognition and best pedagogical practices for supporting their learning.

Section 3, where the teaching standards are summarized. This is the conceptual framework from the technological and pedagogical knowledge necessary to teach any VET course, but focused on the IoToAI curriculum, as example to inspire teachers.

Section 4, where the research-driven models of innovative pedagogical practices for the effective implementation of the VET teacher training program in blended learning are identified, comparing online and face to face models. These models also aim at supporting teachers to develop the teaching readiness standards established in the previous part. The pedagogical framework is drafted to guide the development of the teacher training program in ways that will equip teachers with the knowledge and skills required to

[1] This toolkit complies the result of the work performed by the partnership of the European project IoToAI, mainly the Intellectual Output 3, composed of tasks 3.1 Conceptual Framework, task 3.2 Teaching standards and task 3.3 Identifying the pedagogical models for teacher training program in blended learning.

[2] IoToAI project, website https://iotoai.infoproject.eu

implement innovative instructional methodologies and curricula that will equip students for digital leading and for technical jobs.

In Sections 5 and 6 show a set of examples of blended courses in different fields of study in VET and the IoToAI course as an example of blended learning course to plan, design and implement.

Finally, Section 7 concludes with a list of recommendations to consider if blended learning is used as an educational method for teaching-learning.

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2. Conceptual framework- technological and pedagogical knowledge for integrating digital technologies

The digital transformation paradigm, which includes the fourth Industrial revolution or Industry 4.0, the Enterprise 4.0 and the Circular Economy 4.0, has opened the door to push the development of new training paths (continuous training) in VET, providing students with a novel training offer digital-tech oriented aligned with the current and future job demand. In this new training paradigm, disruptive technologies and digital tools will/are being included in the training curriculums, not only in IT profiles, but also in Social Science and Humanities (SSH). It implies that training providers, teachers and learners must be ready to this new training scenario where some technical and pedagogical knowledge and skills are required for and effective teaching-learning process.

In this section, the conceptual framework is summarized, from the technological and pedagogical knowledge necessary to effectively integrate innovative training contents focused on ICT. The conceptual framework is based on research knowledge about student cognition and best pedagogical practices for supporting their learning. The curricular subjects developed in the framework of the IoToAI project are also included as example to inspire. These are focused on ICT topics such as IoT, Cloud, AI, Big Data, etc.

2.1. Digital transformation skills in VET. Competences required for teachers

The teaching activities in VET focused on training the digital transformation skills will demand new competences in teachers in the full stack of the training programs: curriculum design, organization of training provision, ICT contents, assessment, etc. Table 1 is provided as example of methodology for analysing the competences expected for VET teachers.

Students will also need to satisfy some requisites for an effective teaching-learning in digital transformation competences. Independently of the training method (f2f, blended or online), they should be familiar with ICT, at least as user level, with interest in new technologies, and open mind for new promoting their development of skills in digital issues.

Finally, training providers will need to support teachers in the adoption of new training programs and new teaching-learning process, with the human resources, facilities, technology and continuous training for teachers if required.

Table 1 Example of matrix for analysing general competences required for VET teachers in the training of digital transformation technologies

	Professional competences (knowledge/skills) in the field of expertise	Pedagogical- didactical competences (skills for transmitting knowledge, training methods, approaches)
Curriculum design and development	Ability to define competences and qualifications focused on the novel technical approaches in the digital transformation paradigm and to identify and to work on decision making in the curriculum design of newly emerging competences by identifying and forecasting needs. Ability to update curricula referring to the dynamic changes in the digital transformation.	Abilities to identify, select, organize, develop and test the pedagogical didactic approaches suitable for the provision of the competences emerging from the digital transformation.
Scheduling the training provision	Ability to analyse the paradigms of the digital transformation and extract their didactical issues. Ability to identify the most effective ways of the organisation of the novel training content.	Ability to analyse, test, apply and optimise the training organization, technological and learning processes. Ability to identify, select and adjust methods and top training/learning approaches in the digital transformation context.
Training methods and approaches	Ability to identify effective training/learning methods and approaches for developing the emerging competences (in the digital transformation context).	Ability to identify and develop methodical approaches for the development of process-oriented attitudes and approaches to teaching/learning with technologies. Ability to identify, develop and test didactic approaches and methods that facilitate holistic understanding of the theoretical and practical teaching-learning work based on interactions learners-ICT tools.
Assessments of competences	Abilities to identify and test the criteria and tasks of assessment of newly emerging competences referring to their contents.	Abilities to identify and test the formative assessment methods and approaches of newly emerging competences.

2.2. Use case: knowledge and skills required by teachers to implement IoToAI training program

The IoToAI program has been defined, designed and developed in the framework of IoToAI project. A set of training units has been identified as key topics for promoting learners' digitalization skills development. As figure 1 shows, these are organized in training modules, with four different levels according to the level of difficulty or learners' knowledge: 0-level (grey), 1-level- Introductory (A/blue), 2-level- Main (B/yellow), 3-level- Advanced (C/green).

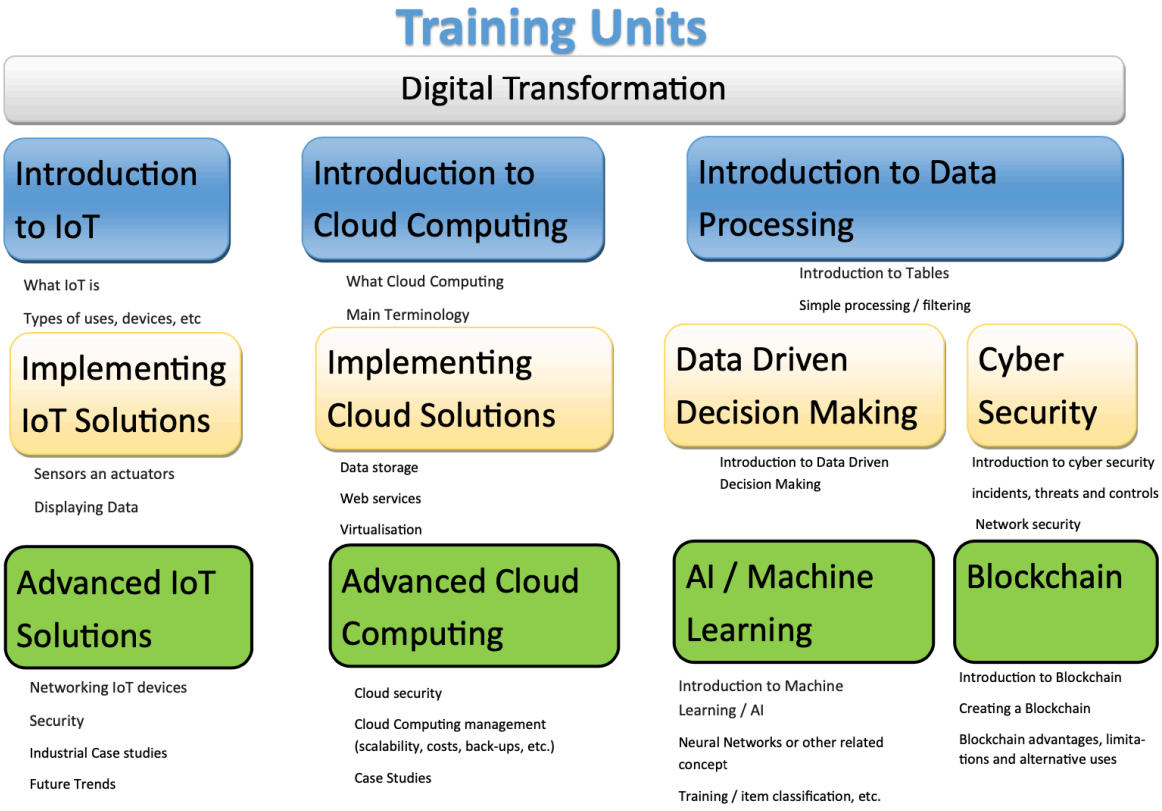


Figure 1 Block diagram of IoToAI training program organised in modules- training units.

For each training unit in the IoToAI program, a list of technical and pedagogical skills and knowledge has been identified as those required by teachers for a success implementation of the teaching-learning process, independently the teaching-learning model (f2f, blended, online). The analysis is focused on the teachers' profile, module by module.

For each module a matrix has been designed, with a similar structure as the one provided in table 1. Each matrix-module (from tables 2 to 5) is organized as follows: each row is a training unit in the module. Each column represents the features analysed: training unit content (index of training program), skills required by teachers in specific technical/digital tools (driver tools for teaching-learning approach in the topic) and technical skills required by teachers (focused on the topic).

The pedagogical needs of teachers have been also enumerated, but in a single matrix (table 6) for the full IoToAI program, since pedagogical needs are more focused on cross-layer skills among all training contents.

The results in this analysis serve as a framework for helping teachers to implement each module of IoToAI program in their VET studies or other training programs.

Let us review each level module and the analysis performed for each one.

0-level module:

This level consists of a single training unit: Digital transformation. The goal is to introduce the learners in the concept and main features of the digital transformation, the challenges, organization strategies and case studies of success implementation of digital transformation.

In table 2, the technical knowledge and skills required by teachers for implementing this module are summarized. Table 6 summarizes the pedagogical requirements.

1-level module: Introductory

The introductory level consists of three training units:

- Introduction to IoT.
- Introduction to Cloud Computing.
- Introduction to Data Processing.

These training units are designed for providing the learners a general overview about some technologies involved in the digital transformation, technical features, use cases and practical exercises (if required). Table 3 summarizes the technical skills and knowledge demanded to teachers, while table 6 the pedagogical ones.

2-level module: Main

The main level consists of four training units:

- Implementing IoT Solutions.
- Implementing Cloud Solutions.

- Introduction to Data Driven Decision Making.
- Cybersecurity

These training units are designed for providing the learners practical skills in those training contents (IoT and Cloud) already introduced in a previous module, while provides a general overview about some specific technologies in data processing: data analytics and Cybersecurity, both highly claimed in the digital transformation. Other technical issues, use cases and practical exercises (if required) are also introduced in these training units.

As in the previous module, the technical knowledge and skills required for teachers are summarized in a matrix, table 4. The pedagogical needs are provided in table 6.

3-level module: Advanced

The advanced level consists of four training units:

- Advanced IoT Solutions.
- Advanced Cloud Solutions.
- Artificial Intelligence / Machine Learning.
- Blockchain.

The two former training units are designed for providing the learners high-level knowledge and skills in theoretical/practical issues about IoT and Cloud. In the branch of Data processing, AI and Machine Learning (ML) is included as a training unit in this module, due to the advanced level in tech. and maths required for its understanding. Blockchain is also introduced in this advanced level, hot topic in the digital transformation for secure data transactions.

The technical knowledge and skills required for teachers are summarized in table 5, and the pedagogical ones in table 6.

Table 2 List of technical skills and knowledge required by teachers in the IoToAI training program: 0-level module.

Training unit	Index of training units	Skills in specific Technical/digital tools	Technical skills/knowledge required
Digital transformation	What is digital transformation? The stages of digital transformation Should your organization digitally transform? Who is involved in the digital transformation process and how long does it take? What is a digital transformation strategy? How do I digitally transform? Digital transformation case studies Practical exercises	Teachers should understand the capabilities of Google Analytics, Keyword Planner and Google Search Console.	Knowledge of associated Digital Transformation Frameworks: - The 7 Principles of Digital Business Strategy. The 'In-Side-Out/Outside-In' Model. A business or consulting background would be a distinct advantage. Thorough knowledge of the case studies as provided as part of the content. An appreciation of the groups within an organisation needed to drive Dx and their role in the process (organisational structure)

Table 3 List of technical skills and knowledge required by teachers in the IoToAI training program: 1-level module: Introductory.

Training unit	Index of training units	Skills in specific Technical/digital tools	Technical skills/knowledge required
Introduction to IoT	Introduction to IoT IoT challenges The IoT environment IoT applications and use cases Practical exercises	Ability to manage and use IoT devices such as sensors and actuators. Ability to manage and interact with IoT networks, concretely the ability to establish communications based on the protocol IPv6. Ability to use at least two of the recommended IoT platforms: Google Cloud Platform, IRI Voracity, Amazon AWS IoT Core or Microsoft Azure IoT Core.	Ability to recognize and identify the main characteristics and benefits of IoT and their subsequent technologies, such as augmented reality or edge computing. Capacity to define and explain the four-layer IoT architecture basics, from the detection layer to the application one. Skill to enumerate the main scenarios where IoT can be applied, highlighting the role of IoT in society in general.
Introduction to Cloud Computing	What is Cloud Computing Cloud Computing overview Virtualisation Adopting Cloud Computing Case studies	Some experience/knowledge of Cloud Computing Technology Understanding of the principles around cloud computing and the main types (IaaS, PaaS, SaaS)	Understanding of cloud computing is required along with an understanding of the difference between cloud and on-premise solutions. Ability to distinguish among types: IaaS, PaaS, SaaS. Knowledge about the case studies used in the notes.
Introduction to Digital Processing	What is data processing Types of data processing Data visualization Applications of data processing Practical exercises	Knowledge of data processing is required, with basic knowledge of Excel and Access core skills required for the labs.	Detailed understanding of data processing. Ability to collect and process data provided in source documents, at this stage the processing/sorting algorithms are basic

Table 4 List of technical skills and knowledge required by teachers in the IoToAI training program: 2-level module: Main.

Training unit	Index of training units	Skills in specific Technical/digital tools	Technical skills/knowledge required
Implementing IoT solutions	Introduction to IoT IoT Devices IoT Networks Device Management. Platforms Digitalization and IoT	Ability to teach student on how to deploy and configure IoT devices with commercial development IoT kits for starter users, such as IoT Kits for Arduino or Starter kit for IoT based on Raspberry Pi. Ability of basic use in main technologies related to IoT networks and communications: Near Field Communication (NFC), Wireless Sensor Networks (WSN), Zigbee or LoRa. Ability to establish basic communications based on the IPv6 protocol. Ability of advanced use in at least three of the recommended IoT platforms: Google Cloud Platform, IRI Voracity, Amazon AWS IoT Core or Microsoft Azure IoT Core.	Abilities to understand and transmit the key points of an IoT environment based on a four-layer architecture. Ability to categorize the types of IoT device based on their roles or application ranges to facilitate the assessment of the election IoT devices according to different scenarios. Abilities related to know how an IoT network works, how to use technologies for IoT Networks and protocols. Ability to transmit why is essential to manage devices in an IoT environment by leveraging the benefits of using IoT platform in device management.
Implementing Cloud	Cloud Computing overview Cloud architecture	Knowledge and experience in at least 2 cloud platforms, such as AWS, Azure and Google cloud.	Be proficient in the following areas: • Cloud Technology

Computing solutions	Storage Hardware Virtualisation Application development Additional applications	Knowledge of virtualisation using Oracle Box and VMware. Programming experience, especially in relation to services and web services.	• Virtualisation • Programming / application development Basic understanding of networking concepts.
Introduction to Data Driven Decision Making	Introduction to Data Driven Decision Making 5 Secrets of Data Driven Decision Making Data Driven Decision Making – Strategic Planning Data Driven Decision Making Leadership Case Studies	A working knowledge of online tools: - Google Analytics, Google Trends, Google Console, Keyword Planner	Sources of data and why this is important to organisations Basic understanding of customer trends, demand and intent and that can be derived from data sources Basic knowledge of MVP's (Minimum Viable Product) Thorough understanding of the case studies as contained in the content
Cybersecurity	Intro to Cyber Security Cyber Security Incidents and Threats Cyber Security controls / Countermeasures Network security Cyber security scenarios- the job place	Internet tools such as: the email client, browser configuration. Antivirus, VPN and Firewall at user level Office tools.	Advanced Knowledge level of internet concepts: client/server model. Knowledge of how cryptography works. Basic Knowledge of data security concepts: data back-ups, password control.

Table 5 List of technical skills and knowledge required by teachers in the IoToAI training program: 3-level module: Advanced.

Training unit	Technical content (index training unit)	Skills in specific Technical/digital tools	Technical skills/knowledge required
Advanced IoT solutions	IoT environment overview IoT platforms and development tools Network architectures LoRaWAN Labwork- deployment of a LoraWAN network	Ability to develop IoT applications by using concrete IDEs and IoT Tools like Google IoT Core. Ability to use development framework aimed at deploying and configuring LoRaWAN networks.	Ability to have at least the same technical skills and knowledge required for the previous training units related to IoT. Ability to know in-depth details of an IoT environment with special interest on skills for IoT deployment y different real scenarios. Ability to design IoT networks that connect IoT devices by using commercial platforms. Ability to configure and deploy LoRaWAN network.
Advanced Cloud Computing	Cloud Computing overview Network utilisation Application development Data processing Resource management Additional services	Experience in at least 2 cloud platforms, the most common are AWS, Azure and Google cloud. Knowledge of virtualisation using Oracle Box and VMware A Programming experience, especially in relation to services and web services	Be proficient in the following areas: • Cloud Technology • Networking • Programming / application development Knowledge of cloud-based virtualisation Basic understanding of data processing concepts

		Good knowledge in operating with networking (fundamentals, IP addressing / subnets, network security)	
Artificial Intelligence / Machine learning	Background & Setting the Scene Practical AI AI Explored AI - Ethics	Experience of basic online tools of Artificial intelligence like www.quickdraw.withgoogle.com and www.teachablemachine.withgoogle.com	A broad understanding of AI as it applies in the business world. Basic understanding of the AI framework as detailed in the content. Basic knowledge of structured vs unstructured data, reinforcement learning and supervised vs unsupervised learning. Knowledge of case studies as delivered in the content. Basic understanding of the ethics associated with AI and its possible implications on a workforce.
Blockchain	Theory of blockchain Blockchain technologies Practice: development tools Extra (current panorama / new trends)	Knowledge in at least one Programming environment (IDLE) such as Eclipse, Netbeans, Visual Studio, etc.	Basic knowledge of centralized databases like MySQL Knowledge of the basics of cryptography and hash functions, software protocols and Internet protocols. Skills in programming with object-oriented languages such as Java, C++ or C#.

Table 6 Pedagogical knowledge required by teachers in the IoToAI training program.

Level	Training units	Pedagogical skills /knowledge for effective teaching-learning
0	Digital Transformation	Should be able to link and refer to the basic principles of digital transformation with the case studies provided, connecting the theoretical with the business examples in a 'real-world' setting
1	Introduction to IoT	Abilities to seek out, select, analyse, organise, develop and test didactic pedagogical approaches adequate for the delivery of IoT competences at a basic level by putting the light on the comprehension of the key points of an IoT environment.
	Introduction to Cloud Computing	Abilities to analyse case studies in relation to cloud computing and test didactic pedagogical approaches adequate for the delivery of cloud computing competences at a basic level.
	Introduction to Digital Processing	Abilities to analyse, process and present / visualise data for the delivery of data processing competences at a basic level.
2	Implementing IoT Solutions	Abilities to seek, select, analyse, organise, develop and test didactic pedagogical approaches centred on a clear understanding of the key ideas useful for basic IoT developments for various scenarios to be applied in.
	Implementing Cloud Computing Solutions	Skills to select, analyse and apply cloud computing concepts (cloud architecture and cloud-based data storage) and hardware virtualisation. This will include testing didactic pedagogical approaches centred on a clear understanding of the key concepts in cloud computing.
	Introduction to Data Driven Decision Making	Should be able to link and refer to the basic principles of data analytics with the basic tools mentioned and be able to illustrate their place/how they could be leveraged within a business/real world setting
	Cybersecurity	Should be able to link and refer to the basic principles of the cyber security and be able to illustrate the cyberattacks and measures/countermeasures for them within a business/real world setting.

3	Advanced IoT solutions	Skills to search for, select, analyse, organise, develop and test didactic pedagogical approaches suitable for actual IoT deployments in general that can enhance the learning of skills related to IoT deployments from a practical point of view.
	Advanced Cloud Computing	Skills to select, analyse and apply cloud computing concepts and technology and test didactic pedagogical approaches suitable for cloud computing (primarily cloud architecture configuration, cloud-based data processing, cloud based application development) that can enhance the learning of skills related to cloud computing from a practical point of view.
	Artificial Intelligence / Machine learning	Should be able to link and refer to the basic principles of AI/ML with the basic tools included as part of the module and be able to illustrate their place/how they could be leveraged within a business/real world setting
	Blockchain	Skills of teaching the technical and independent concepts under blockchain: cryptography, hash functions, a block, a chain of blocks, and develop them in an object programming language to understand how a basic blockchain works in a practical way. Should be able to link and refer to the basic principles of blockchain with the case provided, connecting the theoretical with the blockchain uses in a 'real-world': cryptocurrencies, smart contracts, NFTS

3. Teaching standards

The teaching standards are related to the conceptual framework for the technological and pedagogical knowledge necessary to teach any curriculum. In this regard, the domain analysis establishes a comprehensive set of required competences demanded to teachers, the so-called teaching readiness standards. These are identified as the knowledge and skills necessary to be ready for effective teaching.

The establishment of teaching readiness standards serve as a framework for promoting and, at the same time, assessing teachers' growing levels of knowledge about the VET program or course, its pedagogy and the impact this might have on the implementation of a curricula.

For the use case of IoToAI program, the teaching standards must focus on how the above features are integrated in computer programming skills such as Cloud Computing, Big Data or AI subjects. Tables 7-17 summarize the teaching standards identified for the IoToAI program. For each training unit in IoToAI, the overview of knowledge and skills requirements are shown as well as the specific technical or skills needed for each section in the training unit.

Table 7 Teaching standards in training unit Digital Transformation.

Unit Name	Digital Transformation	
Level	Introductory	
Audience	ICT managers, workers, students and SSH workers	
Overview of knowledge and skills requirements	This module is at introductory level. No technical knowledge required, but you should have some sample organizations for applying digital transformation principles	
Section	**Description**	**Technical / Skills Implementation**
1. What is Digital Transformation	Introduction to Digital Transformation	No technical knowledge required
2. The Stages of Digital Transformation	Initial overview of the stages of Digital Transformation.	No technical knowledge required Knowledge of a business or organisation for applying digital transformation principles
3. Should your Organisation Digitally Transform?	This section illustrates the reasons an organization needs to digitally transform	No technical knowledge required Knowledge of a business or organisation for applying digital transformation principles
4. Who is Involved in the Digital Transformation Process and How Long does it Take?	This section shows the people within an organization who should be involved in Digital Transformation and why.	No technical knowledge required
5. What is a Digital Transformation Strategy?	This section looks at examples of a digital transformation strategy	No technical knowledge required
6. How do I Digitally Transform?	This section illustrates how an organization should digitally transform	No technical knowledge required
7. Digital Transformation Case Studies	Examples of real businesses who successfully went through the process of digital transformation	No technical knowledge required

Table 8 Teaching standards in training unit Introduction to Internet of Things.

Unit Name	Introduction to Internet of Things	
Level	Introductory	
Audience	ICT - managers, workers, students, SSH - managers, HE workers, students	
Overview of knowledge and skills requirements	In this training unit the teacher will need a full understanding about the Internet of Things paradigm, focused on how implementing IoT can be a solution for not only ICT-based enterprises but also in higher-education SSH professional contexts.	
Section	**Description**	**Technical / Skills Implementation**
1. Introduction to IoT	Introduction to the IoT technology and its importance in the digital transformation in the industry (Industry 4.0 or Enterprise 4.0 paradigms) and different business sectors.	Knowledge of the main characteristics and benefits of IoT and their subsequent technologies, framed in the smart cities, smart factories, Industry 4.0 or Enterprise 4.0 paradigms. Technical knowledge about IoT is required
2. IoT challenges	Highlight and explain the current IoT challenges opening the door to new business opportunities that leveraging the IoT advantages	Knowledge of the main challenges of IoT in the current and future industry and business. Technical knowledge about IoT is required
3. The IoT environment	To give a general knowledge about a traditional IoT scenario and the role of IoT devices, networks, and platforms	Skills in the four-layer IoT architecture basics, from the detection layer to the application one. Technical knowledge about IoT is required
4. IoT applications and use cases	To show different uses cases of IoT in several ICT industrial and possible application in SSH enterprise scenarios	Knowledge of main scenarios where IoT can be applied and highlighting the role of IoT in society in general. Technical knowledge about IoT is required

Table 9 Teaching standards in training unit Introduction to Cloud Computing.

Unit Name	Introduction to Cloud Computing	
Level	Introductory	
Audience	ICT managers, workers, students and SSH workers	
Overview of knowledge and skills requirements	This module is at introductory level. Some experience / knowledge of Cloud Computing Technology is required. You will need to understand the principles around cloud computing and the main types (IaaS, PaaS, SaasS).	
Section	**Description**	**Technical / Skills Implementation**
1. What is Cloud Computing	Introduction to cloud computing	Some experience / knowledge of Cloud Computing Technology is required No technical knowledge required
2. Cloud Computing Overview	Initial overview of why to use cloud computing	Knowledge of the principles around cloud computing and the main types (IaaS, PaaS, SaasS) required. No technical knowledge required
3. Virtualisation	This section explain what virtualisation is and its benefits	Knowledge of what virtualization is and its benefits No technical knowledge required
4. Adopting Cloud Computing	This section covers the stages in adopting cloud computing and the problems you may face	Knowledge of the principles around cloud computing and the main types (IaaS, PaaS, SaasS) required. No technical knowledge required

Table 10 Teaching standards in training unit Introduction to Data Processing.

Unit Name	Introduction to Data Processing	
Level	Introductory	
Audience	ICT managers, workers, students and SSH workers	
Overview of knowledge and skills requirements	This module is at introductory level. Knowledge of data processing is required, with basic knowledge of Excel and Access core skills required for the labs.	
Section	**Description**	**Technical / Skills Implementation**
1. What is Data Processing	Introduction to data processing	None No technical knowledge required
2. Types of Data Processing	Main types of techniques in data processing	Basic mathematical skills required Basic knowledge of Excel for performing calculations Basic knowledge of Access
3. Data Visualization	This section demonstrates data visualisation tools (Excel and Power BI)	Excel for creating charts Power BI demonstration included, familiarize yourself with the example before unit delivery
4. Applications of Data Processing	Main applications of data processing in modern technologies	None No technical knowledge required

Table 11 Teaching standards in training unit Implementing IoT Solutions.

Unit Name	Implementing IoT Solutions	
Level	Main	
Audience	ICT managers, workers, students, SSH workers and students that completed	
Overview of knowledge and skills requirements	In this training unit the teacher will need some experience on IoT, knowledge in detail of the agents that compose the IoT environment, such as devices, protocols or networks.	
Section	**Description**	**Technical / Skills Implementation**
1. Introduction to IoT	This section reviews the Internet of Things context by outlining the scope, and current challenges for IoT	Knowledge of the main characteristics of IoT, current and future challenges. Technical knowledge about IoT is required
2. IoT Devices	This section illustrates the different types of IoT devices in business and industrial scenarios, their nature, and their use in different application contexts	Skills in the deployment and configuration of IoT devices by using commercial development IoT kits for starter users, such as IoT Kits for Arduino, or Starter kit for IoT based on Raspberry Pi. Technical knowledge about IoT is required
3. IoT Networks	This section introduces the relationship between an IoT scenario and its network design and implementation	Knowledge of the main technologies related to IoT networks and communications: Near Field Communication (NFC), Wireless Sensor Networks (WSN), Zigbee or LoRa. Ability to establish basic communications based on the IPv6 protocol. Technical knowledge about IoT is required
4. Device Management. Platforms	This section provides a general overview about the role of protocols and IoT platforms in an IoT environment by showing some relevant types and examples.	Knowledge of at least three of the recommended IoT platforms: Google Cloud Platform, IRI Voracity, Amazon AWS IoT Core or Microsoft Azure IoT Core. Technical knowledge about IoT is required
5. Digitalization and IoT	This section shows the symbiosis of the digitalization and IoT data and how its application can become a point of differentiation in the business	Knowledge of the digital transformation technologies and implications, companies / opportunities in the context of IoT use. Technical knowledge about IoT is required
6. Practical Exercise	Practical exercise with regard of a basic IoT deployment and operation in the open-source simulator CupCarbon IoT.	Knowledge and skills with the open source simulator CupCarbon IoT.

Table 12 Teaching standards in training unit Implementing Cloud Computing.

Unit Name	Implementing Cloud Computing	
Level	Main	
Audience	ICT managers, workers, students and SSH workers	
Overview of knowledge and skills requirements	In this module you will need some experience in cloud platforms, the most common are AWS, Azure and Google cloud. You also need knowledge of virtualisation using Oracle Box and VMware.	
Section	**Description**	**Technical / Skills Implementation**
1. Cloud Computing Overview	Introduction to cloud computing	Some experience / knowledge of Cloud Computing Technology is required
2. Cloud Computing Architecture	This section will review the main cloud providers. Identifying the architecture and key concepts around each cloud provider	Knowledge of the principles around cloud computing and the main types (IaaS, PaaS, SaasS) required.
3. Storage	This section demonstrates data storage options in cloud platforms	Knowledge of Cloud Computing Technology storage options for AWS and Azure. Small demo involving using Azure for cloud storage, can be modified for AWS or Google platform
4. Hardware Virtualisation	This section introduces trainees to virtualization. Including hands-on labs.	Experience of virtualisation using Oracle Box or VMware Knowledge of networking fundamentals (IP addressing and subnet masks)
5. Application development	This section illustrates how applications can be developed and deployed to cloud platforms	Basic programming skills required Knowledge of Cloud Computing Technology required, lab developed for Azure.
6. Additional Applications		None

Unit Name	Data Driven Decision Making	
Level	Main	
Audience	ICT - managers, workers, students, SSH - managers, HE workers, students	
Overview of knowledge and skills requirements	In this module you will learn about the importance of using data to driven decisions in the context of a business setting. No Technical knowledge required.	
Section	**Description**	**Technical / Skills Implementation**
1. Introduction to Data Driven Decision Making	A brief overview of what Data Driven Decision Making is	No technical knowledge required
2. 5 Secrets of Data Driven Decision Making	Examples to illustrate how data driven decision making plays out in a business setting. This will develop the correct mindset of data driven decision making.	No technical knowledge required
3. Data Driven Decision Making – Strategic Planning	This module looks at the theory of DDDM and the practical applications in a business setting.	No technical knowledge required
4. Data Driven Decision Making Leadership Case Study	Explore the application of data driven techniques, the tools and how they are applied in practical ways.	No technical knowledge required

Table 13 Teaching standards in training unit Introduction to Data Driven Decision Making.

Unit Name	Cyber Security	
Level	Main	
Audience	ICT managers, workers, students and SSH workers	
Overview of knowledge and skills requirements	In this training unit both basic knowledge about computer and Internet tools (as browser, email or antivirus) and basic knowledge of data security concepts: data back-ups and password control are required.	
Section	**Description**	**Technical / Skills Implementation**
5. Introduction to Cyber Security	Concepts as what is data information of a company, the different areas of data security, phases of a Cyber Attack and C.I.A. concept.	Basic understanding about the different the information security within a company. No advance technical skills are required.
6. Cyber Security Incidents & Threats	Basic understanding about the main types of cyber security incidents based in four questions: • How does it work? • What is the attack goal? • How is it spread/infected/expanded? • How do I protect myself?	Basic understanding about the different types of attacks and their goals. No advance technical skills are required.
7. Cyber Security Controls / Counter measures	Introduce the controls used to protect the CIA (confidentiality, integrity, and availability) of data and information systems.	Basic understanding about the controls. No advance technical skills are required.
8. Network Security	Measures and countermeasures activities to protect the usability, reliability, integrity and safety of the network.	Basic understanding about VPNs and security software as antivirus, firewall… No advance technical skills are required.
9. Cyber security scenarios	How to protect/restore the data after an attack. Contingency plans on a company.	Basic concepts about antivirus, back-ups, data encryption… No advance technical skills are required.

Table 14 Teaching standards in training unit Cyber Security.

Unit Name	Advanced IoT Solutions	
Level	Advanced	
Audience	ICT workers, students with solid knowledge in IoT or that completed B1 module	
Overview of knowledge and skills requirements	In this training unit the teacher will need solid experience in IoT, platforms, protocols, networks and skills for teaching practical work with ThingsBoard.	
Section	**Description**	**Technical / Skills Implementation**
1. Introduction to IoT	This section reviews the Internet of Things context by outlining the scope, and current challenges for IoT	Knowledge of the main characteristics of IoT, current and future challenges. Technical knowledge about IoT is required
2. IoT Technologies, Systems and design principles	This section illustrates the different types of IoT technologies in business and industrial scenarios, their nature, and their design principles to its use in different application contexts	Skills in the context of IoT technologies, devices, topologies, network communications (Near Field Communication (NFC), Wireless Sensor Networks (WSN), Zigbee or LoRa), protocols, applications, middleware. Technical knowledge about IoT is required
3. IoT platforms	This section introduces the landscape of IoT platforms, how they work and the main aspects to consider when choosing a platform provider	Knowledge about IoT platforms, their architecture, device and DDBB management, extra tools, etc. Ability to recognize features of platforms and evaluate pros&cons when a platform must be choosen. Technical knowledge about IoT is required
4. IoT Solutions	This section reviews six of the most widely used IoT platforms by showing some relevant types and examples.	Knowledge of at six IoT platforms: FIWARE; Amazon AWS IoT, Google Cloud IoT, Microsoft Azure IoT, IBM IoT, ThingsBoard. Technical knowledge about IoT is required
5. Labwork ThingsBoard	Practical exercise with regard of a basic IoT deployment and operation in the open-source simulator ThingsBoard	Knowledge and skills with the open-source simulator Thingsboard IoT. Technical knowledge about IoT is required

Table 15 Teaching standards in training unit Advanced IoT Solutions.

Unit Name	Advanced Cloud Computing	
Level	Advanced	
Audience	ICT workers, students with solid knowledge in Cloud Computing or that completed C1 module	
Overview of knowledge and skills requirements	In this module you will need experience in cloud platforms, the most common are AWS, Azure and Google cloud. You also need some networking, programming and data knowledge for specific sections of the course	
Section	**Description**	**Technical / Skills Implementation**
1. Cloud Computing Overview	Overview of the main cloud terminology and implementation concepts	Knowledge of Cloud Computing Technology.
2. Network Utilization	This section focuses on the network configuration of a cloud environment covering sub-nets, security, etc.	Knowledge of Cloud Computing Technology. Knowledge of networking fundamentals
3. Application Development	This section focuses on developing applications to run on a cloud environment.	Knowledge of Cloud Computing Technology. Knowledge of programming fundamentals
4. Data Processing	In this section we process data stored in a cloud environment	Knowledge of Cloud Computing Technology. Knowledge of data processing fundamentals
5. Resource Management	With the cloud computing environment, data and applications developed. We now look at resource management	Knowledge of Cloud Computing Technology. Knowledge of networking fundamentals

Table 16 Teaching standards in training unit Advanced Cloud Computing.

Unit Name	Artificial Intelligence - For Leaders, Managers & Decision Makers	
Level	Advanced	
Audience	ICT - managers, workers, students, SSH - managers, HE workers, students	
Overview of knowledge and skills requirements	This module is an introduction to AI in the context of a business setting. No technical AI knowledge is required, but a basic understanding of the different types of AI and how they are leveraged in a business setting may be helpful	
Section	**Description**	**Technical / Skills Implementation**
6. Background & Setting the Scene	This overview sets the scene as to the importance of AI in a business setting and why business heads need to pay attention	No technical knowledge required.
7. Practical AI	This module will look at the different types of data classifications and how to build an AI, illustrating the potential applications in a business setting.	No technical knowledge required Basic understanding of the different types of AI
8. AI Explored	This module explores the different components of AI and how they can be leveraged in a business setting	No technical knowledge required Basic understanding of the different types of AI
9. AI - Ethics	This module will explore the ethical considerations around the adoption of AI.	No technical knowledge required Basic understanding of the different types of AI

Table 17 Teaching standards in training unit Artificial Intelligence – ForLeaders, Managers and Decision Makers.

Table 18 Teaching standards in training unit Blockchain.

Unit Name	Blockchain	
Level	Advanced	
Audience	ICT workers, students with solid knowledge in programming	
Overview of knowledge and skills requirements	In this module skills in programming with object oriented languages such as Java, C++ or C# are required. Also, knowledge about the basics of cryptography and hash functions.	
Section	**Description**	**Technical / Skills Implementation**
1. Introduction to Blockchain	Basic concept about Blockchain and its live cycle	This section is conceptual, no special technical skills are required.
2. Proof of work (Mining), Simple Wallet and Transaction	Introduction to the basic parts on a Blockchain, illustrated by a programming example.	Skills on programming with Java language. Good understanding about concepts like hash, cryptography, P2P.
3. Blockchain advantages and limitations	Basic description about blockchain advantages and limitations.	This section is conceptual, no special technical skills are required.
4. Cryptocurrencies, Smartcontracts and NFTS	Basic description of the current main uses of Blockchain technology.	This section is conceptual, no special technical skills are required.
5. Blockchain alternative uses	Basic description of the other emergent uses of Blockchain technology.	This section is conceptual, no special technical skills are required.

4. Effective implementation of VET teaching programs in Blended learning

In this section, research-driven models of innovative pedagogical practices for the effective implementation of the VET teacher training program in blended learning have been identified. These models will aim at supporting teachers to develop the teaching readiness standards established by the IoToAI partnership, to effectively implement the teaching and learning training units.

The pedagogical framework is drafted to guide the development of the teacher training program in ways that will equip teachers with the knowledge and skills required to implement innovative instructional methodologies and curricula that will equip students for digital leading and for technical jobs.

The preliminary design of the framework is based on desk research range from exemplary approaches (online, onsite and blended) to teacher digital strategies training across Europe and internationally, after taking into account cultural differences in teaching and learning methods, as well as technical considerations regarding course delivery.

The final goal is to explain to teachers and other interested parties, how to introduce and perform blended curricula in their institutions and colleges, with a focus on the scope of the IoToAI training topics.

This section is organized in a set of subsections: subsection 4.1 gives an overview of blended learning: goals, benefits. Subsection 4.2 goes in depth in popular tools to carry out the teaching-learning process, mainly Learning Management Systems, central to most blended learning courses. Other digital tools are reviewed in subsection 4.3, emphasizing those that enables teaching through gamification and flipped classroom. Subsection 4.4 introduces the steps that teachers should follow for planning and designing blended learning in training courses. Subsection 4.5 describes the steps for an effective implementation of blended learning courses. Finally, subsection 4.6 reviews in depth different methods and tools for performing the student's evaluation in blended learning.

4.1. Blended Learning

Blended learning is an educational method of teaching/learning that enables both teachers and learners to engage in ways that would not normally be available or effective in traditional f2f lessons. This adds value right across the vocational educational sector for both learners and teachers. Learners have an increasing expectation that resources will be available for them to access anywhere and anytime. The act of "blending" achieves better learner experiences and outcomes, and more efficient teaching and course management practices. It can involve a mix of delivery modes, teaching approaches and learning styles [1].

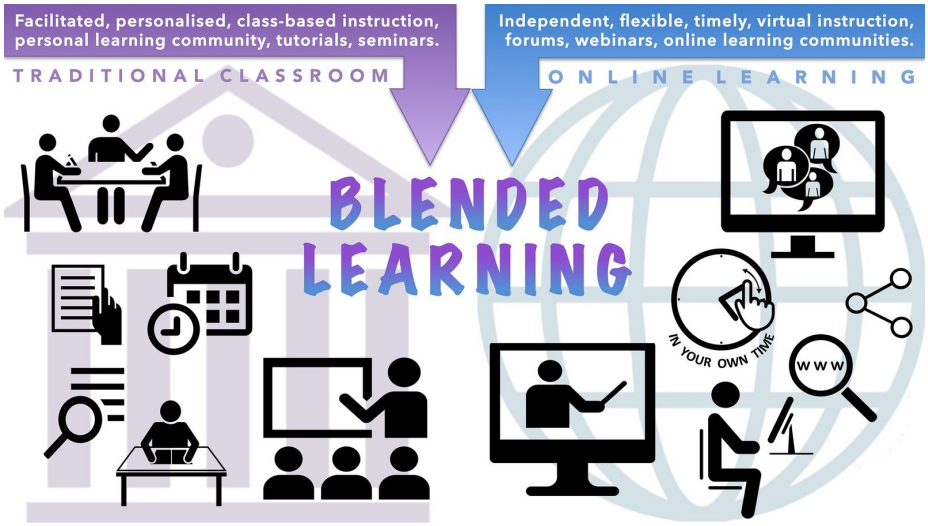


Figure 2 Graphic overview of Blended Learning (source[3] with license CC-BY-NC 2.0)

The Internet and ICTs are the drivers of blended learning, as they are the enablers of the teaching and learning through the blended learning experience. To achieve this, blended teaching/learning is carried out through online Learning Management Systems (LMS), digital platforms like the popular Moodle[4] or Google Classroom[5]. Both, teachers and learners, need a smart device (PC, laptop, tablet, etc.) with Internet access for interacting with the LMS.

[3] https://www.flickr.com/photos/jodieinblack/29155993523
[4] https://moodle.org/
[5] https://classroom.google.com/

Teachers develop and maintain an online space in LMS where they upload videos, notes, slides, docs, etc., available for those students enrolled in their courses. Students can have access to the content anywhere and anytime.

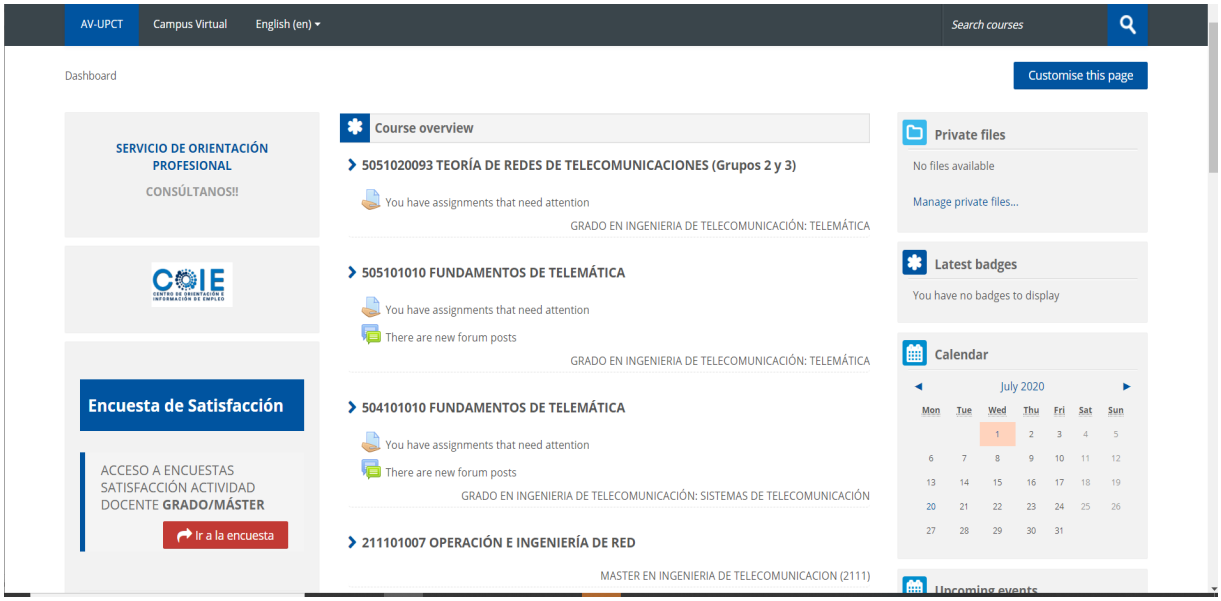


Figure 3 Snapshot of Moodle platform, through a teacher's account, where a set of courses are managed

LMS also allows the launch of assessments and the ability to perform online activities through meetings, chats, group activities, discussion forums etc. Online activities in blended learning can be synchronized or unsynchronized. The former occurs when all participants, teachers and learners, work in real-time. They are usually programmed for resolving queries, problems or offering explanations about content and exercises. The latter is performed when learners access and participate at their convenience, usually for downloading training contents, consulting documents, or performing activities on their own.

4.1.1. Main benefits of blended learning

All participants in blended learning get benefits from it: teachers, students/learners and training providers. The most notable benefits are described below.

For teachers:

- Shows more flexibility in the way the course is structured and delivered, compared with the traditional face-to-face teaching.
- Gives the opportunity for teachers to increase the information and knowledge shared with each other and with students.
- It is easier to provide supplementary training material to students, at any time, by simply uploading or sharing through digital tools.
- Allows learners to engage in a deeper way, using face-to-face time for individual or small groups, helping them to resolve queries, questions, or reinforce the knowledge they acquired during online sessions.
- Enables the creation of a collaborative learning environment in the classroom. In this way, blended learning increases the interaction between teachers and students, because interaction occurs, not only in face-to-face lessons but also through digital tools.
- Increases interactions among students and teachers thanks to the use of email, chat, interactive video calls, digital learning platforms, etc.
- The digital learning platforms used offers teachers' continuous information about the way students are progressing, because they can monitor and check the work that students are performing during the teaching-learning process.
- Enables a better and higher attention to diversity. "Provides a better opportunity for students of varying capabilities to engage in an optimal way".
- Useful for those teachers that want to implement flipped classroom[6].

[6] https://www.theflippedclassroom.es/

For students/learners:

- Enables students to carry out the training course with independence, freedom, flexibility and autonomy.
- Offers access/re-access to a full repository with all resources uploaded by teaches.
- Enables students to organize themselves, their time, be responsible of their tasks, evolution and progress.
- Develops technological skills in students. Students need digital technologies to be enrolled in courses, to carry out the learning process, to interact with teachers, tutors and other students.
- Enhances soft skills in students (those mentioned above), useful for other subjects and for further work development.
- Enhances collaborative learning activities. Students can interact with others, tutors and teachers to perform tasks where they share their ideas and experiences. They can open discussions, participate in debates, and feed a forum/chat where the ideas, doubts and concerns are shared among the learning community.

For training providers:

- Can be delivered with a low Capital Expenditure (CAPEX) if the LMS chosen and the digital tools for supporting the training are freely available. The most popular tools are mentioned in the subsections below.
- The cost of the deployment and service could be low, depending on where the LMS is allocated - the LMS can be installed and run in a proprietary server or in the Cloud. The provider needs to guarantee sufficient space (memory) for storing the LMS and learning contents and online availability in LMS 24/7.
- Facilities can be used efficiently, maximizing its use and reducing the cost of renting and general supplies thanks to the combination of online and f2f teaching/learning activities.
- The cost of teachers' effort is reduced, at least some of the delivery is virtual, and teachers can work from home with their own Internet connection. On the other hand, teachers must be equipped with powerful smart devices and appropriated hardware and software tools.
- Since most of learning supplies are virtual, some operational costs (Operational Expenditure, OPEX) coming from textbooks, paper, photocopies, etc. are minimized.

- Increases the rate of engagement and retention of learners/students. Blended learning offers training not only in the specific Skills and competencies of the course, but also some important soft-skills, such as autonomy, critical-thinking, creativity, collaborative work etc., which are demanded by enterprises.
- Breaks down geographic barriers for providers, offering modern and accessible learning to students placed far-away, who have neither the time nor availability for full-time f2f learning etc.

It is also a benefit when recruiting teachers who are located far from the provider facilities, giving a more flexible schedule.

Table 19 Summary of benefits of blended learning for students, teachers and providers

Role	Main benefits of blended learning
Teachers	More flexibility More creativity Reinforcement of knowledge Perform flipped classroom Increase teacher-student interaction Creation of collaborative learning environment
Students/learners	Independence Autonomy Freedom Flexibility Technological skills
Training providers	Reduce CAPEX and OPEX Increase number of students

	Increase retention rates Increase learner satisfaction Breaks geographic barriers for teachers and learners

4.2. Learning Management System tools

As previously stated, blended learning is mainly supported by LMS tools, enabling teachers and learners to interact with each other when there is no face-to-face communication. This promotes greater access and support for both the learning materials and the people involved in the course; tutors, teachers and other students.

In general, in all LMS, each course is organised and managed by the teachers as a private area, configured and organised by him/her according to the course needs, scope and learning outcomes. In each course, teachers can include chats, forums, space for videos, audios, text, links to other tools, webpages, questionnaires, etc.; available anywhere, anytime. Of course, teachers must ensure that the intellectual property of the content is not being corrupted. LMS can also offer to teachers the access to data analytics about learners' engagement in the materials and activities published.

There are a lot of things to be considered when a LMS must be selected. In general, most of LMS have similar features, that are briefly enumerated in next subsection. However, selecting the right LMS will depend on the final goal. Since there more than one thousand LMS vendors, with many features to choose, it seems useful to identify the top things that are mandatory to consider when a LMS must be selected. They are also discussed below.

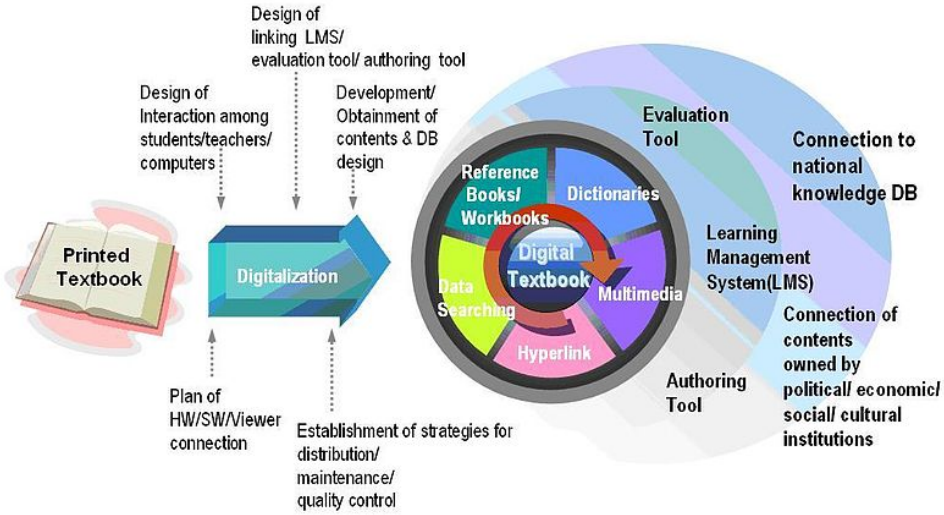


Figure 4 Main features of LMS. (source with license CC-A 3.0)

4.2.1. Main features and top things to consider

Most of LMS offer teachers a set of similar features and extra tools, like:

- Administrator role: where the teachers can manage users, courses, contents, roles, etc., generate reports of interest, etc.
- Calendar tool: it permits teachers to schedule activities, sessions, etc., helping students in their own organization and autonomy in the tasks' development.
- Email box: internal email system for teacher-learners' communications.
- Notification system: to program reminders and automatic notifications to learners and teachers.
- Assessment tool: teachers can design surveys, questionnaires and exams to be launched and distributed, automatically proofreading, marking, etc.
- Certification/training progress/recording tool. Learners can display training progress and certification of course finished, successfully passed, transcript of records, etc.

Then, when a LMS must be chosen, some top things must be considered[7]. They are summarized as follows:

[7] https://elearningindustry.com/the-best-learning-management-systems-top-list

- **Gamification tool:** it is not mandatory but useful for creating attractive training content that engage learners and make the teaching-learning process a funny and valuable tool.
- **Data-Driven results:** from the providers and teachers' side, the feature of tracking and reporting results is an interesting tool. As an example, the reports can help to understand the results of the dropout rate in specific courses, or they can measure the training efforts. It will allow everything from the evaluation of the length of training lessons, statistics around the most/least visits of the training content, to diagnosis of non-attractive training material.
- **Tools for testing and assessment:** They provide evaluation, in different formats regarding the progress and success of the training of the learners
- **Responsive tool:** it is mandatory a LMS tool can be adapted to different/multiple devices and navigators. Then, compatibility and multiple-device support must be a priority.
- **xAPI compliance** – promote personalized learning paths: xAPI compliance is an ideal tool if it is needed to share learning between multiple applications and systems. It is widely used for informal learning and mobile learning. It helps track the learners' progress and, since eLearning nowadays is all about data and personalized learning paths, it is really useful.
- **Multiple languages:** it is useful for the LMS to be Internationally understood and offer training content/courses for people from different countries and languages
- **Course catalogue:** it is useful for the LMS to allow creation of the list/directory of available courses, where the functionality permits searches by keyword, location, lecturer, date and categories.

4.2.2. Commercial LMS vs open source LMS

Out of the previous list, the LMS can be categorised by the way it is provided, distinguishing between commercial LMS and open source LMS. This is a key feature when a LMS must be selected. In the next paragraphs, the advantages and disadvantages of both models are discussed.

Commercial LMS

They are usually allocated in the cloud by an LMS server provider. Hence, the training provider does not have to perform any installation and the deployment is easier and faster. The cost depends on the type of

license acquired, which strongly depends on the features required by the client (training provider). Data security, maintenance, 24/7 support, scalability requisites and updates are guaranteed by the LMS provider. These LMS are usually responsive and adapted to a multiple-location service. Most commercial LMS offer a free trial subscription to try the tool, before taking the decision to invest.

Open source LMS

It is a low-cost solution, but it needs the installation and the setup in the training provider's server (local or in the cloud). This means that the training provider is in charge of the data security, maintenance, scalability, updates, etc. Many features can be found on the Internet, usually developed by a free open-source community. Supports can also be found though forums and users' communities. It is a good, low-cost solution for a small training provider or for those that want to add new features to the LMS tool with their own developments.

Table 20 Comparison of main features between commercial and open source LMS

Feature	Commercial LMS	Open source LMS
Hosting	Cloud/local	Cloud/local
Installation	Easy	Mid/high difficult
Data Security	Guaranteed by LMS provider	In charge of the training provider. Supported by consulting users'/development community and forums
Maintenance		
Scalability		
Updates		
Support	24/7	
Responsive	Yes	Depends on the LMS

Multi-platform (Operative System, OS)	Yes	Depends on the LMS
Extra features	Offered by extra paid	Free by community
Cost	paid	Free
Scope	Big training providers/enterprises	Small/medium training providers or own developments

4.2.3. Cloud-based vs self-hosted LMS

LMS can also be categorised by the place where they are allocated, distinguishing between Cloud-based and self-hosted LMS. This is a key feature in the decision of an LMS. In the following paragraphs, both models are compared.

Cloud based LMS

They are based on Software-as-a-Service (SaaS)[8] model. It is installed in the servers of the LMS providers and accessible via the web. Training providers don't have to install anything on their servers and computers for working with LMS, just to sign in on them. They are usually commercialised by an LMS provider, so the training provider needs to sign up for a plan (fee required) and start working. Once the training provider is registered, it can access to an admin area, customizable for uploading content, set-up course registration, manage users, include branding, etc. According to Technavio[9], by 2020, over 80% of organizations will adopt cloud based LMS because it will help to reduce OPEX, offer flexibility and 24/7 access.

Self-hosted LMS

[8] https://en.wikipedia.org/wiki/Software_as_a_service
[9] https://www.businesswire.com/news/home/20161018005095/en/Gen-LMS-Market-Boom-80-Organizations-Adopt

They require the training provider to install the LMS software in a server, local or in the cloud, using an Infrastructure as a Software (IaaS)[10] model. It also has to maintain the software, manage updates, new features, etc. Although the training provider loses the ease-to-use offered by Cloud-based LMS, it has the full control of the LMS tool.

The main advantages of Cloud-Based LMS are almost the same as those summarised for Commercial LMS in Table 20. This is because most commercial LMS are Cloud-based LMS solutions. But they also present some disadvantages, such as limited customisation and control and integration with other external platforms and cost. Self-hosted LMS are usually cheaper, but nowadays it is easy to find competitive low prices in commercial Cloud-based LMS, with pay models based on, e. g. pay-per-user, pay-per-registered-user or pay-per-active user. The final decision will depend on the needs/capacity of the training provider.

4.2.4. Most popular LMS

There are a lot of reports on the Internet listing the most popular LMS. They vary each year, and sometimes depend on the scope (industry/education), price (free or paid), or if they are sponsored by an interested LMS provider. In table 21, a short ranking of the most popular LMS in 2020 are shown. It is classified according to the scope of e-learning: industry, published by E-learning Industry[11] and education (formal and informal training in VET/HE and other training). This is part of a longer list recently published by g2[12].

Table 21 list of most popular commercial and open source LMS for e-learning in industry

	e-learning in Industry	e-learning for education

[10] https://en.wikipedia.org/wiki/Infrastructure_as_a_service
[11] https://elearningindustry.com/the-best-learning-management-systems-top-list
[12] https://www.g2.com/categories/learning-management-system-lms

Ranking	Commercial LMS	Open source LMS	Commercial/Open source
1	Docebo[13]	Moodle[14]	Canvas[15]
2	Adobe Captivate Prime[16]	Chamilo[17]	Blackboard learn[18]
3	Talent MLS[19]	Open edX[20]	Google Classroom[21]
4	SAP litmos[22]	Totara Learn[23]	Schoology[24]
5	LearnUpon[25]	Canvas	Docebo

Those for industry are distinguished by commercial or open source while in education, the ranking does not distinguish them. Moreover, the source of the ranking for industry does not go into great depth in the methodology in terms of gathering and scoring the user's opinion, something very common in tsese kinds of reports. Fortunately, the source of the ranking focused on e-learning for education explains in depth, the methodology for gathering the users' satisfaction.

Finally, it is strongly recommended that a review of all features of the most popular LMS is taken to make the right decision about which LMS to use.

[13] https://www.docebo.com
[14] https://moodle.org/
[15] https://www.instructure.com/canvas/
[16] https://www.adobe.com/es/products/captivateprime.html
[17] https://chamilo.org
[18] https://www.blackboard.com/
[19] https://www.talentlms.com/
[20] https://open.edx.org/
[21] https://classroom.google.com/
[22] https://www.litmos.com/
[23] https://www.totaralearning.com/
[24] https://www.schoology.com/
[25] https://www.learnupon.com/

4.3. Other digital tools for supporting blended learning

Blended learning is not only focused on the use of a LMS by teachers and learners, but also an opportunity for teachers to enrich training contents and activities using other digital tools. Obviously, their use entails that teachers and learners work with laptops, computers, tablets, or similar smart devices connected to the Internet as well as some digital skills.

In this section some of the most popular digital tools and technologies that support blended learning are reviewed, focusing the review mostly on those with free/open license.

4.3.1. Gamification tools

Gamification is an educational technique that consists of creating games about the contents, exercises and activities, enabling the students to learn in a simple and playful way. Its use is being increased in the classroom, gaining popularity in recent years thanks to the wide list of gamification tools that permit teachers to create games in a simple and easy way.

In this subsection we list and briefly describe some of the most popular freely available gamification tools, based on the ranking published by the Educational Resources portal web[26]. The decision about which tools to use will depend on the needs of the teacher or training provider.

Table 22 List of most popular gamification tools in 2020

Gamification tool	Main features
Brainscape[27]	It allows the creation of flashcard games. It has a repository with a large number and variety of digital teaching cards for a wide variety of subjects. It is easy to install, with a mobile app available (available in iOS and Android).
Knowere[28]	It enables the creation of videogames focussed on maths. It includes interesting and attractive challenges in algebra and geometry.

[26] https://educationalresources.online/essential-gamification-tools/
[27] https://www.brainscape.com/
[28] https://www.knowre.com/

	It is available in an online web platform and is responsive.
Cerebriti[29]	It allows students to create their own educational games and play with games created by others (not only by teachers). There is a repository with games from a wide set of subjects, for different levels. It is available online, free and is multiplatform.
Pear Deck[30]	It permits creation of interactive content such as questions, images or other, and can be sent to individual students, increasing teacher-learner interaction. It is freely available on a web platform.
Kahoot![31]	It allows creation of gambling contests with students, with questions and answers delivered in an intuitive way. It includes supplementary and novel tools for increasing teaching and learning methodologies. It is freely available on a web platform. It includes learning apps for different purposes.

4.3.2. Tools for enriching slide/poster/images-based presentations

There are a lot of alternatives for creating innovative, attractive and funny presentations to engage students' attention. In this subsection some of the most popular in education and freely available are briefly described.

- **Google Slides**[32]: this is a powerful and easy to use web tool for creating attractive presentations. It offers a library with a complete set of themes, fonts, animation effects, video embedding, etc. The only requirement for its use is to have a Google email account. The tool is easy to access, intuitive and enables the user to save the changes automatically and check old versions. The tool enables a collaborative mode. The ability to share for comment, editing of slides and presentation in real time.

[29] https://www.cerebriti.com/
[30] https://www.peardeck.com/
[31] https://kahoot.com/
[32] https://www.google.es/intl/es/slides/about/

- **Prezi**[33] is a powerful web tool that allows the user to create visually appealing presentations. It offers a wide set of templates and a library full of images, text, videos and Zooming features. It also enables collaborative mode for building presentations.
- **Haiku Deck**[34]**:** this is another presentation tool that allows teachers to visually narrate stories. It provides a wide set of themes and templates and an image library to include images in slides. One of the most powerful features of this tool is that it automatically resizes images and shrinks text to fit in the slides. Stories created on Haiku Deck can be automatically shared on popular social networks, embedded in blog posts or exported as .ppt.
- **ThingLink**[35]: this is a web tool that allows users to create interactive images online by adding to text, videos, music or links to the image. It also presents a novel feature: to add interactive pin marks (links to other videos or websites) to YouTube videos.
- **Glogster**[36]: is a web tool and mobile app that allows users to create Glogs, short of graphic blog. The tool is free. It is possible to create interactive posters or multimedia images. Posters can be composed of text, photos, videos, graphics, sounds, drawings, data attachments, etc. It offers a set of predesigned templates and 10,000 educational graphics, categorised by subjects.

4.3.3. Tools for enriching videos

Videos are widely used in education, supporting the main teaching materials in blended learning and online learning [2]. They must be attractive for learners. There are popular tools, freely available, for enriching educational videos by editing them (not recording), adding voice, comments, images, quizzes, etc. The most popular tools are briefly described as follows:

- **EDpuzzle**[37] is an intuitive video editor that enables both teachers and students to add voice-overs, comments, resources and quizzes to existing online videos.

[33] https://prezi.com
[34] https://www.haikudeck.com/
[35] https://www.thinglink.com/
[36] http://edu.glogster.com/
[37] https://edpuzzle.com/

- **PlayPosit**[38]: it is not the most intuitive video editor but enables teachers to add in the videos teaching strategies to pause videos, ask questions/answers, or spark discussions.
- **Comment Bubble**[39]: it enables the creation of lecture feedback in videos or comments, ideal to evaluate or get feedback from students about recent lessons consumed in video. Note that the students' feedback is visible for all students in the virtual classroom.

4.3.4. Tools for screencast

"Screencast" is the term used for digital recording of a video screen capture, sometimes containing audio narration. There are many tools that allow users to perform screencast, providing them with a powerful tool for creating multimedia learning content. A lot of screencast tools can be found on the Internet. They can be classified according to the type of smart device or OS used. The most popular and free tools used by educators, are[40]:

- **OBS**[41] is a free and open-source tool that allows users to stream live and record screencast and audio to a video file. It is compatible with Windows OS. It is not intuitive and requires users to spend some time learning how to use it properly.
- **Camstudio**[42]: it is an open-source program that works with Windows. It can record both visual and audio activity and give you a high-quality recording as a teacher to show your students.
- **Wondershare**[43]. It is a freely available tool for screencast, with a lot of powerful editing features. It allows the uploading of videos to YouTube with just one click and allows students to interact.
- **Google plus hangout**[44]: it is a free to use screencast tool but also includes a collaborative tool for letting students and teachers interact in a live environment. The recordings can be uploaded to YouTube.

[38] https://go.playposit.com/
[39] https://commentbubble.com/
[40] https://filmora.wondershare.com/screen-recorder/best-free-screencasting-tools-for-teachers.html
[41] https://obsproject.com/es
[42] https://camstudio.org/
[43] https://dc.wondershare.com/
[44] https://hangouts.google.com/?hl=en

- **Screencast-o-matic**[45]: it is an easy-to-use screencast that allows the user to record screen, access the webcam and customize videos. It also allows you to add text, audio and image to videos. It has a cost-effective paid version which includes editing features like onscreen drawing and zooming tools.

There are screencast tools for specific devices and OS, such as **Nimbus**[46] or **Screencastify**[47]. For Chromebook users, **ShowMe**[48], **Educreations Interactive Whiteboard**[49] or **Doodlecast Pro**50 for Ipad users, or **Lensoo Create**[51], for recording in Android or IOS screens. Note that some of these tools are not available for free.

The final decision about which screencast tool should be used by each teacher will strongly depend on his/her needs and constraints.

4.3.5. Tools for Flipped classroom

In the last decade, flipped classroom has gained popularity because it enables students to assess their progress, by watching lecture videos, allowing them to pause, stop, replay as they need, as well as allowing them to read learning docs as many times as required (3). Meanwhile the time in the classroom is used for collaboration work and open discussion about the work completed at home (videos consumed, docs read, exercises done, etc.) There are a wide set of digital tools that support the dynamicity of flipped classroom. Some of them have already been mentioned in the subsections above. In this section some new tools are described, classified according to the goal.

1) **Set of educational videos**. There are some open and free online repositories of educational videos, thousands of hours of video lessons for students from different levels, with a lot of subjects. They

[45] https://screencast-o-matic.com/
[46] https://chrome.google.com/webstore/detail/nimbus-screenshot-screen/bpconcjcammlapcogcnnelfmaeghhagj
[47] https://chrome.google.com/webstore/detail/screencastify-screen-vide/mmeijimgabbpbgpdklnllpncmdofkcpn
[48] https://apps.apple.com/es/app/showme-interactive-whiteboard/id445066279
[49] https://apps.apple.com/us/app/educreations-whiteboard/id478617061
[50] https://apps.apple.com/us/app/id469486202?mt=8%3Fuo%3D4
[51] http://www.lensoo.com/create

even extend to topics out of formal training, which is also useful for teachers. Some of the most popular are Khan Academy[52], Ted Edu[53] and Crash Course[54]

2) **Tools for collecting learners' feedback**. These tools are useful when teachers need to know the impact of the teaching method and educational content so they can respond accordingly. These are usually in the form of polls or surveys. Two of the most popular and freely available are Poll Everywhere[55] and Google forms[56].
3) **Tools for enhancing communication**. Flipped Classroom is not solely about consuming educational videos, but also empowering collaborative activities such as: discussions and communication among students and teachers. Hence, digital communication tools are essential. Some of the most popular that are freely available for educators are Google Hangout[57], CampusWire[58] , Discord[59], Kialo Edu[60], Piazza[61], and Zoom[62].
4) **Repositories**: not only the LMS is used as repository. Sometimes teachers need an external repository for uploading videos and educational resources. Helpful features like permitting/preventing people from watching videos, podcast, images are sought after. The most used and freely repositories in education are YouTube[63], Dropbox[64] or Google Drive[65] , among others.

[52] https://es.khanacademy.org/
[53] https://ed.ted.com
[54] https://youtube.com/crashcourse
[55] https://www.polleverywhere.com/
[56] https://www.google.com/intl/es_es/forms/about/
[57] https://hangouts.google.com/
[58] https://campuswire.com/
[59] https://discordapp.com/
[60] https://www.kialo-edu.com/
[61] https://piazza.com/
[62] https://zoom.us/education
[63] https://www.youtube.com/
[64] https://www.dropbox.com/
[65] https://www.google.com/intl/es_es/drive

4.4. Steps for planning and designing a blended learning course

When a blended learning course is designed, the main priority is to provide a teaching-learning process that combines the three pillars of blended learning (f2f lessons, online lessons and collaborative work), with a transversal layer of digital tools that support students. This offers flexibility, captures the students' needs by engaging them and encouraging them to continue, thus minimizing the dropout rate. The teacher also has to fulfil the curriculum design, constraints and outputs. That is, to adjust the design to the Learning Outcomes (LO), curriculum content, learning needs, pedagogic approach and assessment methods.

In this section a guidance on how to perform the planning and design of a blended learning course is provided. Note that not all courses meet the minimum requirements for blended learning. Hence, this phase is mandatory for analysing in depth, the course to determine if it is suitable for performing the adoption and how to do it.

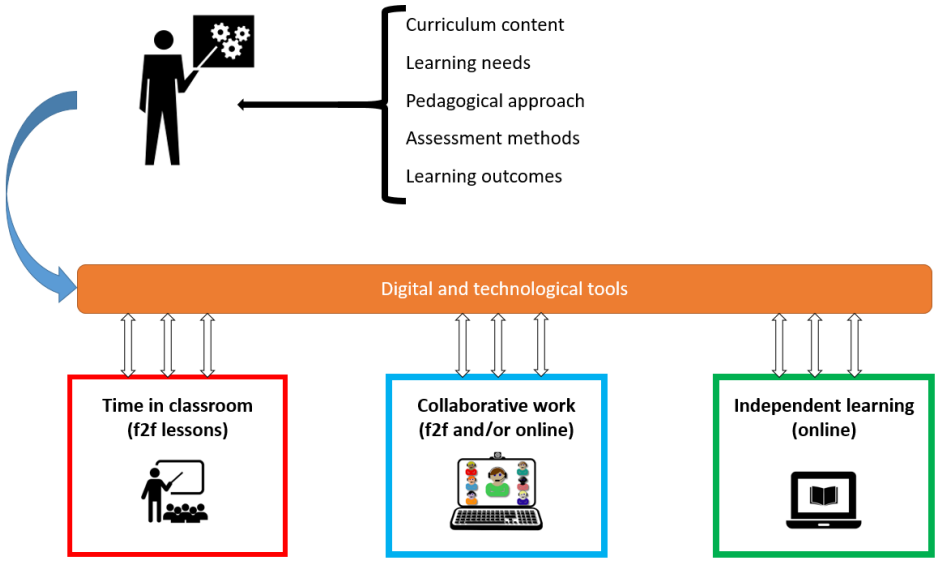


Figure 5 Main actors in the planning and design of blended learning.

Planning is key at the initial stage of the transition from a f2f to a blended approach. It consists of a set of steps of analysis and decision-making to follow. In this toolkit, this planning is suggested in three steps: (1) the course planning itself, (2) facilities and technological/human resources planning from the training providers point of view and (3) the planning from the learners' perspective. All of this is described below.

Course planning.

The course planning is a work of analysis and decision-making to be done by the teacher in charge of the existing course. It consists of three steps:

- Firstly, it is necessary to review the existing course. This means to review the course goals, learning objectives, teaching activities, teaching strategies, assessments and tools (table 23).
- For each teaching activity in the existing course, to calculate the LO that should be reached, the strategies to engage students, the assessment activities and the supporting tools (table 24).
- Finally, for each training activity, to analyse its migration to online mode (table 25). This will depend on the LO to achieve and the activity itself. You should also consider if there are digital tools that enable the training activity and if teachers and learners' profile have the digital skills required for performing the activity online. To do that, it is recommended reviewing section two of this toolkit, focused on LMS and digital tools for blended learning.

Table 23 List of suggestions for reviewing features in an existing course

	Features to review in the existing course
Goal	What are the main goals of the course?
Learning objectives	What are the specific learning objectives (measurable) that students have to reach?
Teaching activities	What teaching activities are planned and what learning objectives are performed in each of them?
Assessment activities	Type of assessments activities. How these activities capture the learning of students? How these learning activities measure the knowledge acquired in terms of LO?
Strategies to engage students	What teaching activities are applied for meeting the goals in students? How the strategies reach the student attention?
Supporting tools	Tools and resources used in teaching/assessment activities and reach the goals

Table 24 Matrix to list teaching activities linked with LO, assessment, tools, etc.

Teaching activity onsite	Description	LO	Assessment activity	Strategy to engage students	Supporting tools
1					
2					
3					
….					
n					

Table 25 Matrix to fill the tentative adoption of existing training activities/assessments to online mode.

Teaching activity online	Migrate to online mode?	Available tools for conversion to digital content	Available tools/strategies for assessment	Available tools/strategy for engage students	Other supporting digital tools
1	Yes	Yes	Yes	Yes	No
2	No				
3	Yes	Yes	No	Yes	Yes
….	Yes	Not sufficient	Yes	Yes	Yes
n	No				

During the analysis of the existing course, it is strongly recommended to analyse those aspects that could be improved, not only from the teaching perspective, but also from the learners. For instance, the use of an online mode in some activities could be an opportunity to increase the teacher-learner communication. This may be because learners feel more comfortable using digital tools to share their opinion, even introverted students. Some of the digital tools listed in section two in this toolkit can serve as inspiration to teachers.

Facilities and technological/human resources planning

In parallel with the blended course planning, the teacher in charge must ensure that the training provider has or can offer the facilities and hardware/software resources required for the blended learning to perform. Moreover, extra human resources will be needed, not only for developing the new digital content, but also for technical issues during the development of the blended learning: preparing labs, devices or to solve software/hardware issues, etc.

In table 26, a list of questions and answers are set as an example. The answers will determine the capacity of the training provider (and teachers) for performing blended learning in the current status, with a short-term solution or mid-term solution. The CAPEX/OPEX and time consumed for solving the need will determine the final decision

Table 26 Planning facilities and technological/human resources in blended learning with set of answers as example for inspiration.

Question	With current facilities and resources	Extra facilities/resources required with cost	Short-term solution	Mid-term solution
LMS available for launching blended course	Yes / No	Yes->extra memory in server, extra cost Yes-> rent a commercial LMS, extra cost No	No in commercial LMS, extra costs cannot be funded Yes, find stable solution, reasonably priced cost, with scalability for new blended courses Yes-> install open LMS because you have ICT professional for supporting and maintenance	No in commercial LMS, extra costs cannot be funded Yes-> install open LMS because you have ICT professional for supporting and maintenance Yes, find stable solution, reasonably priced cost, with scalability for new blended courses
Internet connection sufficient bandwidth for online/streaming/f2f lessons (high number of students connected simultaneously)	Yes / No	Yes → increase bandwidth involves extra cost No	No, extra costs cannot be funded Yes, find Internet supplier that fits the requirements	No, extra costs cannot be funded Yes, find Internet supplier that fits the requirements

Question	With current facilities and resources	Extra facilities/resources required with cost	Short-term solution	Mid-term solution
Teachers involved in the course have ICT skills for performing blended learning	Yes/ No	No, but they can train themselves with free training courses in short time. No, they can train themselves with training courses in short time, extra cost	No, extra costs cannot be funded Yes, commitment of teachers to carry on the training	No, extra costs cannot be funded Yes, commitment of teachers to carry on the training
Technical ICT for supporting/maintenance hardware/software	Yes/ No	No, staff share the tasks, no extra cost Yes, a technician is required, extra cost	No, extra costs cannot be funded Yes, to subcontract the service to an ICT professional	No, extra costs cannot be funded Yes, to hire an ICT professional for permanent support and maintenance
Labs or classroom with computer and ICTs resources for teachers in f2f lessons	Yes / No	Yes, multimedia desks involve extra cost No, there is projector, the teacher can use his/her own computer and connect to the available projector	No, extra costs cannot be funded Yes, rent ICTs resources	No, extra costs cannot be funded Yes, buy ICTs resources

Question	With current facilities and resources	Extra facilities/resources required with cost	Short-term solution	Mid-term solution
Labs or classroom with computers for students in f2f lessons	Yes/No	No, reduce size of students group in f2f Yes, more computers are required, extra cost	No, extra costs cannot be funded Yes, rent ICTs resources	No, extra costs cannot be funded Yes, buy ICTs resources
The scheduler f2f/online activities overlap with the courses offered by the training provider, no sufficient space/teachers	Yes/No	No, increase students' group in f2f for reducing use of facilities/need of new teachers Yes, rent more facilities for avoiding overlap, extra cost Yes, to hire new teachers, extra cost	No, extra costs cannot be funded Yes, rent/buy new facilities Yes, to hire new teachers, extra cost	No, extra costs cannot be funded Yes, rent/buy new facilities Yes, to hire new teachers, extra cost

Learners needs

Finally, it is also important to know if the learner will be able to adapt or is interested in blended learning. The blended learning must be appropriate in format and performance. The learners' profile and his/her needs will determine this. Then, it is recommended to analyse in depth some features of expected learners, using surveys, data analytics or similar techniques. It is required to know if learners:

- Have ICTs skills required for blended learning?
- Have facilities/resources for performing online lessons and activities on their own?
- If their family/work commitments can affect their learning process.
- If their socio-economic situation can affect their learning process.
- If their cultural differences/language can affect their learning process.
- If their maturity is sufficient for blended learning (autonomy, self-organization, etc.).

The information collected will help teachers to evaluate and consider dedicated learning paths for those learners with difficulties or problems to be adapted to a blended learning format.

Finally, if the planning phase finishes with a successful result, the teacher in charge of the adoption to blended learning should design the strategy for carrying out the process. It is recommended to list the action points agreed from each analysis, classifying them as mandatory, short-term or mid-term action. In table 27, an example with some key action points about how to perform the design of an existing course is shown, just to inspire teachers in the task.

Some other questions/answers that can help to feed the design task are:

- What do I expect from the face to face/online lessons?
- How can I add extra support for learners during online lessons/tutoring?
- What are the benefits for teachers participating in blended learning?
- How can I promote blended learning among students/teachers?
- How can I support learners who lack ICT skills?
- How to balance worktime between f2f and online activities to not overload students.
- How much time the teacher has to spend for adopting the course to blended learning.

Lastly, due to the exceptional pandemic situation of Covid-19 experienced during the academic year 2019-2020, (which is expected to continue in 2020-2021), it is recommended teachers include in their planning

and design process, a contingency plan that reflects the adoption of the blended learning course to a 100% online course, just in case.

Table 27 Example of matrix for blended learning course design.

	Mandatory action	**short-term action**	**List of mid-term action**
Course planning	Take decision of training activities online, onsite Decide digital tools to use for each online training, assessment, collaboration and communication activities. …	Generate the digital content in suitable format. Upload digital content in LMS or other digital repositories agreed …	To launch data analytic module for receiving feedback about digital content downloaded, consulted, etc. ….
Facilities and technological/human resources planning	Prepare classroom for f2f lessons with computers Training teachers for new digital tools to use Increase bandwidth in Internet connection …..	Change Internet contract to a provider with better bandwidth Subcontracting ICT support …	
Learners needs	Contact vulnerable learners for support ….	Launch tutoring digital tool for ensuring teacher-learner contact ……	Launch surveys for monitoring learners' satisfaction and needs …

4.5. Steps for implementing a blended learning course

As stated in the previous subsection, and concluded also in [4], the success of the application of blended learning will be determined by the (1) infrastructure, (2) integration (IT, content, and learning process), (3) professional development (teacher, student, and information system management), (4) Support (policy and financial) and (5) culture (attitude). Furthermore, it should be a priority that teachers have the soft skills required to master the pedagogical knowledge of designing instructional models. With the characteristics of VET, specific skills are required for effectively simulating real working conditions, so it can be easily understood by students. Finally, an open attitude in accepting ICT as drivers in the learning culture within the organization is also important for the successful implementation of blended learning in VET.

With all these requisites in mind, the implementation must be performed following one or more (combined) blended learning models. In the scientific literature, many different models are found. To provide a shorter but useful catalogue in this toolkit, only the most popular/applied, are introduced in this section.

Staker and Horn [5] present four models of blended learning that they categorize as the most blended learning programs across the K-12 sector. These are:

- **Rotation model:** learners, under a fixed schedule, rotate among different learning modalities, one of them online learning. Other modalities include f2f lesson, collaborative work, group projects and individual tutoring.
- **Flex model:** the course is organised with a main content delivered in online mode. Students move on an individually customised schedule with online, f2f and offline activities. The teacher provides f2f support as requested, in small groups or individually.
- **Self-blend model** (also called **A La Carte model**)**:** learners take one or more online courses to supplement traditional f2f courses. Learners have the freedom of choosing between online and f2f courses at their convenience. In this model, the tutoring activities are online.
- **Enriched-virtual model:** learners organise their time between attending f2f activities and online learning activities, with a set timetable.

Rotation model is also branched into four categories:

- **Station Rotation model**: allows students to rotate through stations (online, onsite, f2f, collaborative and individual activities) on a fixed schedule or at the tutor's decision.

- **Lab Rotation** is like the Station Rotation model except that the online lessons are organised in a computer lab. This model generally requires the coordination of a set of teachers. One benefit of this model is that using the lab frees up classroom space for other activities within the rotation
- **Flipped Classroom:** as introduced in section two, the lectures and homework is inverted. Learners work at home with material prepared for lectures (watching videos, reading, listening, recording work, etc.) and work in lectures consist of discussing the content worked at home in collaborative activities.
- **Individual Rotation**: learners rotate through stations (online, onsite, f2f, collaborative and individual activities), but on individual schedules set by the teacher. Learners may not necessarily rotate to every station, but only to the stations the teacher has put on their schedule.

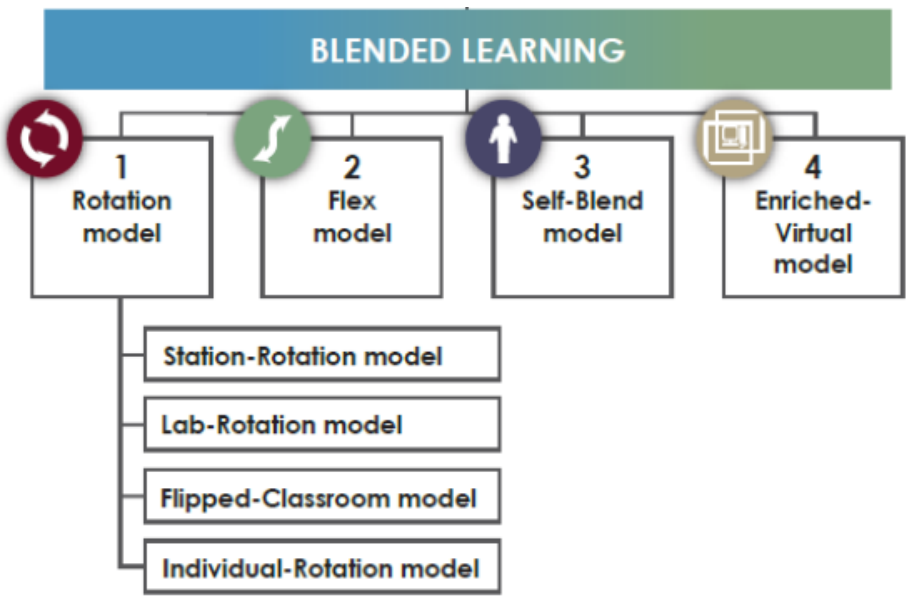


Figure 6 Blended Learning models by Staker and Horn [5]

4.6. Students' evaluation in blended learning

The goal of evaluation is to gather information about learners to analyse and conclude, not only if learners have reached the skills, knowledge and competences expected, in terms of LO, but also, to evaluate the success of the blended learning in the course itself.

Evaluating in the blended learning environment entails the same as a f2f course, however, the "blend" could entail an additional barrier when the learners must be evaluated using technology.

In [6] the authors recommend performing the evaluation considering three main areas:

- Pedagogic: the learning activities to evaluate what the learners have acquired in terms of knowledge
- Resources: the content and supporting docs provided to the learners
- Delivery strategies: the mechanisms for delivering the course; structure, program, organization, tools, etc.

In next subsections different methods of evaluation and frameworks found in the scientific literature are reviewed.

4.6.1. Evaluation methods

In the evaluation, it is important to consider how/when/where the information is gathered. The data collection is usually collected with a combination of quantitative and qualitative methods. Among all existing evaluation methods, some common/popular used in blended learning are:

- Tutor questionnaires
- Learner questionnaires
- Classroom observations
- Individual/group interviews
- Tutor interviews

Moreover, it is recommended to get feedback at different stages in the timeline of the program: Firstly, at the beginning, to know the level of learners before they start the course, at mid-term, to know the evolution in the teaching-learning progress, and in the end, to evaluate if the learners acquired the skills/knowledge/competences expected. It is also interesting to ask learners when a novelty is introduced in the teaching-learning process, for example, when an unknown digital tool is going to be used in a new

activity. Finally, it is necessary to provide an open question where learners can expose their concerns, suggestions for improvements in the course for the future, etc.

In the literature we can find different methods of evaluating blended learning programmes [6], which differ in their methods regarding the data they use, the aspects of blended learning they are focussed on (e. g. training content, technology used), the criteria set to evaluate the success of the blended learning curricula, or other issues about the individuals involved in the blended learning (learners, teachers, training providers, other staff).

In general, the evaluation criteria in blended learning are a combination of three outputs: course outcomes, learners' satisfaction, and student engagement. These are described in depth in next paragraphs.

Course outcomes

Course outcomes are evaluated through different measurements, such as: activities and assessments grades and marks, attendance and dropout rates. The advantage of blended learning in this aspect is that the learners can be continuously measured thanks to the data analytics. Teachers, through the LMS, can obtain useful information about the learners' motivation and attitude, thanks to the analysis about the attendance, interactions and training content consumed in the LMS, attitudes towards learning and the role of the blended learning system in facilitating this.

Learners' satisfaction

The learners' satisfaction cannot be captured through attendance or assessment data, but it is an important data point because it shows the learners' personal experience in the blended learning course. The learners' satisfaction is measured through self-questionnaires about their opinion within the course overall, teaching quality, content quality, digital tools quality, blended learning environment, communication strategies among students and teachers, course flexibility, etc. This data is useful to measure the overall satisfaction, to promote the course for other/future learners.

Learners' engagement

This measure is a more complex analysis than the previous mentioned. Engagement is important in VET/HE sector, because nowadays education is a worldwide competitive marketplace. To manage data regarding the learners' engagement can be an institutional advantage when trying to retain and attract new learners. In [7] the authors identified three elements of learners' engagement: behavioural, emotional and cognitive. They are generally defined as follows [8]:

- **Behavioural:** it is focused on the learning actions, e.g., class attendance, activities submitted, collaboration in activities, contribution in class discussions, etc. Measurements about behaviour are usually collected through questionnaires or classroom observations.
- **Emotional:** it is focused on the affective reactions of learners in relation to their learning, e.g., learners can report they are (or not) interested in the course and they are enjoying the learning. Measurements about learners' emotions are usually collected through direct questions during their learning or classroom experiences.
- **Cognitive:** it is focused on the psychological investment of learners during the learning process, e.g., the desire of learners to go beyond the requirements of the training lessons. Measurements about learners' cognition are not easy. Cognitive engagement mostly relies on questionnaires that try to capture strategies used by learners during the learning.

4.6.2. Evaluation frameworks

A lot of evaluation frameworks can be found in the literature. Although there is a wide set of methods available, no one particular tool seems to be the most effective for evaluating blended learning. In next subsections we review some of the most popular frameworks.

4.6.2.1. Web-Based Learning Environment Instrument (WEBLEI)

WEBLEI is a questionnaire designed for identifying the learners' perceptions and experiences about the online learning experience. It is organized in four different areas [9-10]:

- Emancipatory activities (convenience, efficiency and autonomy)
- Co-participatory activities (flexibility, reflection, quality, interaction, collaboration and feedback)
- Qualia (success, confidence, accomplishments and interest)
- Information structure and design (how well the course and learning materials are structured and designed)

These are scored using a five-point Likert scale. Some studies have included an additional survey with open questions for a more in-depth analysis [11].

4.6.2.2. Hexagonal E-Learning Assessment Model (HELAM)

HELAM is a framework focused on evaluating the LMS in terms of perceived learners' satisfaction, and does not consider the perceptions of teachers, training providers or other staff [12]. It consists of six dimensions, assessed with a questionnaire. Figure 7 summarizes the HEALM framework.

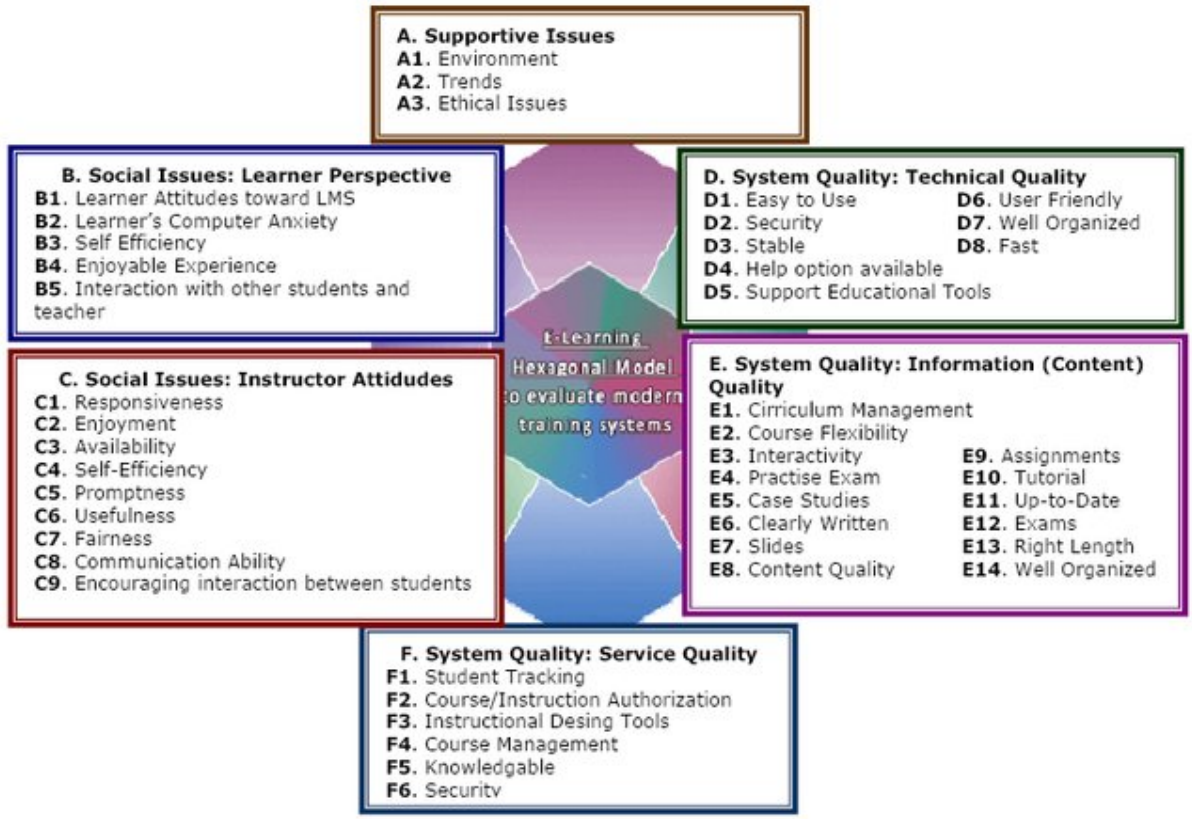


Figure 7 HELAM (Hexagonal E-Learning Assessment Model) [12].

4.6.2.3. E-Learning framework

The E-Learning framework consists of eight dimensions, provided as a guidance in the design, development, delivery and evaluation of open and distributed learning environments, by Khan, B.[66]. The dimensions are interconnected, as is shown in figure 8. This framework has been used to evaluate blended learning, as stated in [13] and [14].

Figure 8 E-learning framework (Khan, B.)

4.6.2.4. Technology Acceptance Model (TAM)

This framework is focused on the technology aspects of blended learning and how it affects the learners' satisfaction and course retention [15]. The perception is captured as follows:

- Perceived usefulness: the degree to which a learner believes that using a particular system would enhance his/her performance
- Perceived ease of use: the degree to which a learner believes that using a particular system would be free from effort.

[66] e-learning Remote Learning Framework and Models | remote learning, e-learning, mobile, blended learning, distance learning, & MOOCs (asianvu.com)

Note that blended learning cannot be evaluated only on technological aspects, since there are other concerns that have influence on the course effectiveness.

4.6.2.5. Rubric-based frameworks

There are many standards and rubric-based frameworks for evaluating blended learning. The reason comes from the fact that rubrics enable the evaluation of a wide range of items: technology aspects, instructional aspects, learners' experiences, etc. They are a quick and efficient way for teachers to evaluate their blended learning courses. There are some remarkable examples of rubric frameworks in the literature, reviewed in depth in [6]. However, rubrics can be subjective in the way the responses are interpreted. Some terms in the responses (e. g. limited, adequate or extensive) have an open interpretation.

5. Examples of blended learning resources and courses in different fields of study in VET

A lot of examples of blended learning approaches, recommendations, toolkits, etc. can be found in the literature, a few of them focused on different fields of study in VET. In next table we provide a summary of those that can help as example of inspiration.

Table 28 Examples of blended learning resources and courses.

Title	Description
Apprenticeship in Greece: focusing on e-learning of a blended learning approach for training vet teachers and trainers [16]]	Scientific paper of a case study in Greece, where a blended learning approach for training VET teachers is explained.
Use Case Based Blended Teaching of IoT Cybersecurity in the Industry 4.0 Era [17]	Scientific paper of a case study in Spain, where blended learning in Industrial Internet of Things and Cybersecurity in the framework of Industry 4.0 is explained.
Examples of Blended Learning [18]	Chapter included in/from? the book Essentials for Blended learning with some case studies of blended learning in different education levels.
Exploring Blended Learning Approaches for VET[67]	European project focused on the development, implementation, performing and evaluation of pilots of blended learning in older adults a VET in different EU countries.
Technical Innovation in Blended Learning[68]	European project focused on the development, implementation, performing and evaluation of pilot courses in C-VET

[67] http://www.blend4vet.eu/
[68] https://www.tibl-project.eu/web/en/

VET practitioner resource[69]	Australian centre of Vocational Education Research that offers a repository of teaching, training and assessment resources
Vocational Educational and Training 4.0[70]	European project focused on the development and implementation of innovative learning modules for VET students and teachers in the fields of electronics and mechatronics
ICTs and Blended Learning in Transforming TVET[71]	The UNESCO-UNEVOC International Centre in Germany offers a repository with examples from around the world in the use of ICTs and novel forms of open, flexible and technology-enhanced learning in TVET
TELU repository[72]	TELU is a collection of free online courses, specifically designed to help educators to get the most out of technology in blended learning

[69] https://www.voced.edu.au/vet-practitioner-resource-teaching-learning#Blended
[70] http://vet-4-0.eu/
[71] https://unevoc.unesco.org/home/UNESCO+and+COL+Publication+on+ICTs+and+Blended+Learning
[72] http://telu.me/case-studies/

6. IoToAI training course as blended learning approach. Conceptual framework

This section introduces the IoToAI course as an example of blended learning course to plan, design and implement. In the IoToAI project, the partnership has been working on the development of a VET program focused on some KET identified as drivers of the digital transformation. These have been primarily identified in an in-depth analysis performed by the partnership, available in [19]. Then, the IoToAI consortium has applied the useful guidelines of this toolkit for performing the training programme, addressing the following tasks:

- Definition of training units and learning outcomes
- Design and organisation of training paths
- Skills, knowledge, competences and evaluation methods
- Training materials development & Pilot Test

The three first tasks have been addressed simultaneously. The training programme has been organized taking as input the analysis reported in this work, as well as the outputs of IoToAI project, available in this website[73]. The KETs finally selected are: introductory topic about Digital Transformation, IoT, Cloud Computing and Data processing, which includes Data Driven Decision Making, Artificial Intelligence, Machine Learning, Data Security and Blockchain. As figure 9 shows, these are renamed as training modules, and they have been organised in three different levels according to the level of difficulty or learners' knowledge: Introductory (A/blue), Main (B/yellow), Advanced (C/green).

Note that the IoToAI partnership have the necessary skills for developing the training material decided, as well as the digital skills for performing the development of a training program for blended learning.

[73] https://iotoai.infoproject.eu

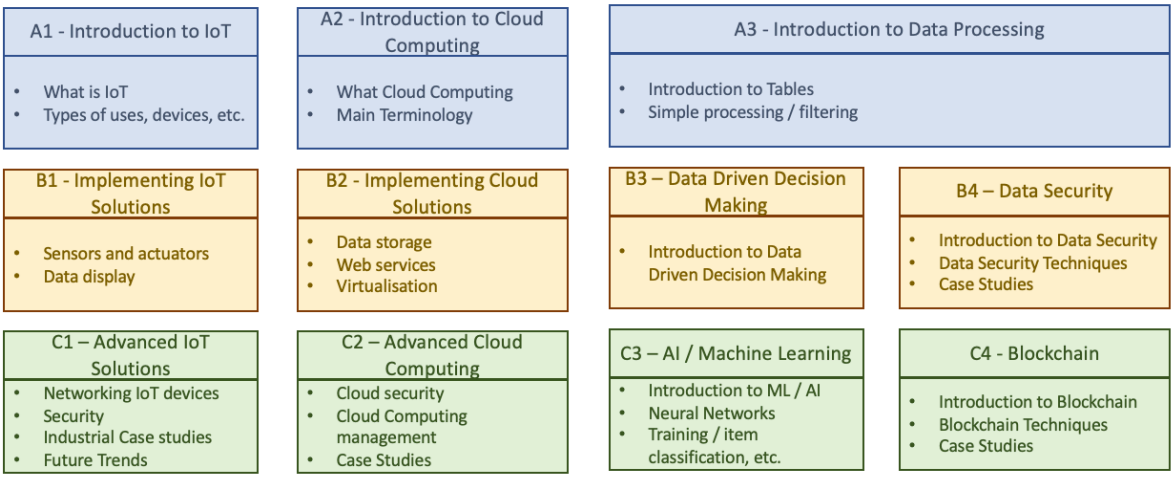


Figure 9 block diagram of IoToAI training program/units.

For each training module, one or more training units have been defined. Each of them is described, identifying the main contents, goals and target users (figure 10).

Code and Name: A1 – Introduction to Internet of Things	
Level of Expertise: Introductory	
SUBJECT	**OBJECTIVES**
1. What is Internet of Things 1.1 Definition 1.2 Context in the industry/companies	Acquire basic knowledge about IoT their importance in the digital transformation in the industry (Industry 4.0 or Enterprise 4.0 paradigms) and different business sectors.
2. Types 2.1 Devices 2.2 Pros and cons 2.3 Application range 2.4 …	Be able to identify the different types of IoT devices in business and industrial scenarios, their nature and use.
3. Use cases	Learn different uses cases of IoT in several industrial and enterprise scenarios.
4. Other subjects	

Figure 10 Example of training unit description in the IoToAI training program.

The training contents described in each training unit are the path for identifying the LO (figure 11) following the guidelines of the EC[74]. These are described as a set of knowledge, skills, and competences, and must be in accordance with the European Qualification Framework (EQF) and National Qualification Framework (NQF) of each partners' country.

Qualification	TBD		
Unit	A2 – Introduction to Cloud Computing		
EQF Level	NQF levels		
	UK	Italy	Spain
4	RQF Level 3	EQF 4	EQF 4
Associated ECVET points	10		
Learning Outcomes			
Sub-units	Knowledge	Skills	Competences
Introduction to Cloud Computing	The learner should... - Explain cloud computing key concepts. - Be able to compare cloud services to conventional on promise solutions	The learner is able to... - Identify business and technical requirements for a basic cloud computing configuration	The learner is capable of... - Identify situations suitable for the use of cloud computing - Compare different cloud providers and the services they offer
	The learner should ... - Explain virtualisation - Identify potential applications for virtualisation.	The learner is able to... - Develop a virtual machine instance	The learner is capable of... - Contrast the performance of a virtual instance in comparison to a physical instance
	The learner should ... - Define the steps involved in adopting cloud computing	The learner is able to... - Develop a basic cloud computing set-up	The learner is capable of... - Review a real scenario in relation to cloud computing.
Assessment Criteria	Not yet defined		

Figure 11 Example of LO description for a training content in the IoToAI training program.

The training material development is one of the most important parts in the conceptual framework of the training programme and its development depends on some decisions being taken, as a result of the analysis performed in this document. In table 28, the main features in the training development are described, together with the considerations and options and the current decision taken by the IoToAI partnership.

The decisions taken in each feature are explained as follows:

- Open-source solutions (LMS/tools): since the EC encourages open-source solutions, the IoToAI consortium decided to use only open-source LMS tool and digital tools for supporting blended learning.
- Cloud based solutions: LMS cloud-based enables a better installation, maintenance, scalability, etc. Hence, this feature was mandatory for the IoToAI LMS.
- Easy access: the access to the IoToAI LMS will be through the official website of IoToAI project, because the IoToAI consortium is understood as the training provider of the IoToAI training program.

[74] https://www.cedefop.europa.eu/en/events-and-projects/projects/learning-outcomes

- User requirements for LMS access: this decision is still pending because the IoToAI training program will firstly be tested in a set of Pilots launched in the UK and Italy. Depending on the results of these pilots, the final user requirements will be decided and set.
- Digital tools for supporting blended learning. In this decision, the IoToAI consortium has considered two powerful tools that provide the training content in a friendly, animated, and gamified format if required. Note that IoToAI launches the training course in two different Pilots in the UK and Italy, with two organizations leading the performance of this training: BMC[75] and CEIPES[76], respectively. The LMS offered by BMC will be Canvas, a web-based LMS. Canvas, briefly introduced in Section 4.2. includes a variety of course creation and management tools that will allow for the creation of a unique and varied learning experience for the modules. On the other hand, a LMS[77] developed by CEIPES will work as powerful e-learning platform, accessible via web. The training contents will be offered with a clear structure. Each module will have an animated video in order to have a friendly and easy format to be follow. Inside each module there will be practical exercises to be done in order to better involve the learners and teachers in the training path. Moreover, other powerful tools such as those provided by the European Project Indie[78], are considered as a useful open-source set of digital tools that works as repository, for uploading all digital content (images, audio, video, text, etc.), embedded in a single repository. Since UPCT is involved in Indie and it is also a partner in IoToAI, the support and maintenance is guaranteed, and the extension of the tool with other extra features, not included in the current version, are easier to reach, thanks to a personalized develop.
- Blended learning model. The IoToAI consortium is preparing the training content with a guide of recommendations and guidelines for instructors to offer the training program in blended learning, combining the different models teachers want to implement. This toolkit will be suggested in the guideless as manual for getting in depth with the blended learning model suggested.
- Note that the final decision about the model to perform also depends on the teachers' schedule, training provider facilities and other mandatory issues that the IoToAI consortium cannot manage.
- Evaluation method. The IoToAI partnership has planned different evaluation methods for the training units, according to their LO. Each training unit, (due to its content and level) could demand a different way to monitor and evaluate its course outcomes, learners' satisfaction, and learners'

[75] Belfast Metropolitan College
[76] Centro Internationale per la promozione dell'Educazione e lo Sviluppo
[77] https://mooc.ceipes.org
[78] http://indie.upct.es/

engagement. Generally, learners' questionnaires will be used for monitoring course outcomes, together with tutoring questionnaires. The individual/group interviews and other type of monitoring tools will be recommended in the guidelines for instructors, using this toolkit as a manual for getting in depth with the evaluation methods suggested.

Note that those decisions concerning training provider resources (facilities, technological and human resources) are not included in the IoToAI conceptual framework because the IoToAI partnership covers all requirements about these issues, at least for launching the IoToAI training program in blended learning during the Pilot tests scheduled in the IoToAI project framework.

Table 29 Main topics-decisions taken during the IoToAI training development.

Topic	Options /considerations	Decision
Blended Learning	Yes/No/Partially (% onsite, % online)	Yes. Pilot 100% online due to covid-19
LMS tool	Top things to consider Commercial vs open source Cloud based vs host-based Use, link, domain, access User requirements	Yes Open Source Cloud based Linked to project webpage To be decided by the IoToAI partnership
Digital tools for supporting blended learning	Gamification tools Tools for enriching videos/presentations Tools for screencast Tools for flipped classroom Others	Yes (IndieAuthor[79]) and others Yes (IndieMedia[80]) and others Yes (OBS, Camstudio) and others Under demand by each IoToAI partner Yes (IndieGenerator[81]) and others
Blended Learning model	Station Rotation model Lab Rotation Flipped classroom Individual Rotation Flex model	Training content prepared for use in all blended learning models. Guidelines for instructors/teachers and list of recommendations is added in the IoToAI training program.

[79] http://indie.upct.es/INDIeAuthor.php
[80] http://indie.upct.es/INDIeMedia.php
[81] http://indie.upct.es/INDIeGenerator.php

	Self-blend model Enriched-virtual model	
Evaluation methods	Tutor questionnaires Learner questionnaires Classroom observations Individual/group interviews Tutor interviews	Not a common methodology. Each training unit is designed to be evaluated according to its LO, monitoring course outcomes, learners' satisfaction, and learners' engagement. Generally, learners' questionnaires will be used for monitoring course outcomes, together with tutoring questionnaires.

7. List of recommendations

Finally, a list of recommendations is provided to be used in the design, planning and development of a training course in blended learning mode. These recommendations summarize the conclusions extracted from all sections in this toolkit.

- Since not all courses meet the minimum requirements for blended learning, it is necessary that the teacher(s), together with the training provider, perform a planning and design of a blended learning course to determine if it is suitable for performing the adoption and how to do it. It is strongly recommended to follow instructions in Section 3, where the course planning is presented as a work of analysis and decision-making. This section also explains how to perform the facilities and technological/human resources planning and the analysis of learners needs. Note that he the success of the application of blended learning will be determined by the (1) infrastructure, (2) integration (IT, content, and learning process), (3) professional development (teacher, student, and information system management), (4) support (policy and financial) and (5) culture (attitude).
- From the above, it is remarked that the main drivers of blended learning are Internet and new technologies. Hence, teachers and learners will need to be familiar and be equipped with smart devices (PC, laptop, tablet) etc., for carrying out the blended learning experience.
- Although the use of an LMS is not mandatory in blended learning, it is strongly recommended, because it can be used, not only as the main repository of the training content, but also as the digital tool for the teacher-learners' online activities and interactions.
- The selection of an LMS will depend on the requisites and constraints. Top things to consider and other features to consider were summarized in Sections 4.2.
- Since blended learning is an opportunity for teachers to enrich training contents and activities using other digital tools, it is strongly recommended to develop training activities and resources using some of the tools enumerated in Section 4.3. These tools will enable the teacher to include

in the training gamification and flipped classroom activities, innovative and attractive slide/posters/image-based presentations, enriched videos, etc.

- All the above recommendations are only applicable if the teacher(s) have, not only the soft skills required to master the pedagogical knowledge, but also a set of ICT skills necessary for performing a successful blended learning course.
- There are different models of blended learning. They can be applied as single or combined. It is recommended to investigate about them in order to evaluate which of them fits better with the blended course in mind.
- It is necessary to implement an evaluation method that enables teacher to gather information about the learners' progress and the success of the blended learning itself. Evaluation is to gather information about learners to analyse and conclude, not only if learners have reached the skills, knowledge and competences expected, in terms of LO, but also, to evaluate the success of the blended learning in the course itself, coming from some key indicators: course outcomes, learners' satisfaction, and student engagement. The most common/used evaluation methods and frameworks are reviewed in Section 4.6
- Finally, don't forget to check other successful stories about blended learning courses. A lot of examples can be found in the literature and Internet. In this report, some of them have been enumerated in Section 6.

8. References

[1] Bath, D. & Bourke, J. (2010). Getting Started with Blended Learning. *Griffith Institute for Higher Education*.

[2] Benkada, C. & Moccozet, L. (2017), Enriched Interactive Videos for Teaching and Learning, *21st International Conference Information Visualisation (IV)*, London, pp. 344-349.

[3] Martinez-Ferrerira, J.M. (2014). Flipped classrooms: From concept to reality using Google Apps, *11th International Conference on Remote Engineering and Virtual Instrumentation*, At: Porto, Portugal.

[4] Bruggeman, R., Tondeur, J., *et. al*. (2021), Experts speaking: Crucial teacher attributes for implementing blended learning in higher education, *The Internet and Higher Education*, 48, ISSN 1096-7516.

[5] Staker, H., & Horn, M. B. (2012). Classifying K-12 Blended Learning. Mountain View, CA: *Innosight Institute*.

[6] Bowyer, J. & L. Chambers (2017), Evaluating blended learning, Bringing the elements together, *Research Matters.*

[7] Fredricks, J. A., Blumenfeld, p. C., & Paris, A. H. (2004). School Engagement: potential of the Concept, State of the Evidence. *Review of Educational Research*, 74(1), 59–109.

[8] Trowler, V. (2010). Student engagement literature review. *The Higher Education Academy*, 11, 1–15.

[9] Tobin, K. (1998). Qualitative perceptions of Learning Environments on the World Wide Web. *Learning Environments Research*, 1(2), 139–162.

[10] Chang, V. (1999). Evaluating the effectiveness of online learning using a new web based learning instrument. In Proc. of *Western Australian Institute for Educational Research Forum.*

[11] Chandra, V., & Fisher, D. L. (2009). Students' perceptions of a blended web based learning environment. *Learning Environments Research*, *12*(1), 31–44.

[12] Ozkan, S., & Koseler, R. (2009). Multi-dimensional students' evaluation of e-learning systems in the higher education context: An empirical investigation. *Computers & Education*, *53*(4), 1285–1296.

[13] Deegan, D., Wims, P. & Pettit, T. (2015). The potential of Blended Learning in Agricultural Education of Ireland. *International Journal of Agricultural Science, Research and Technology in Extension and Education Systems*, *5*(1), 53–64.

[14] Gomes, T., & Panchoo, S. (2015). Teaching Climate Change Through Blended Learning: A case study in a Private Secondary School in Mauritius. In Proc. of *International Conference on Computing, Communication and Security (*ICCCS), (pp.1–5).

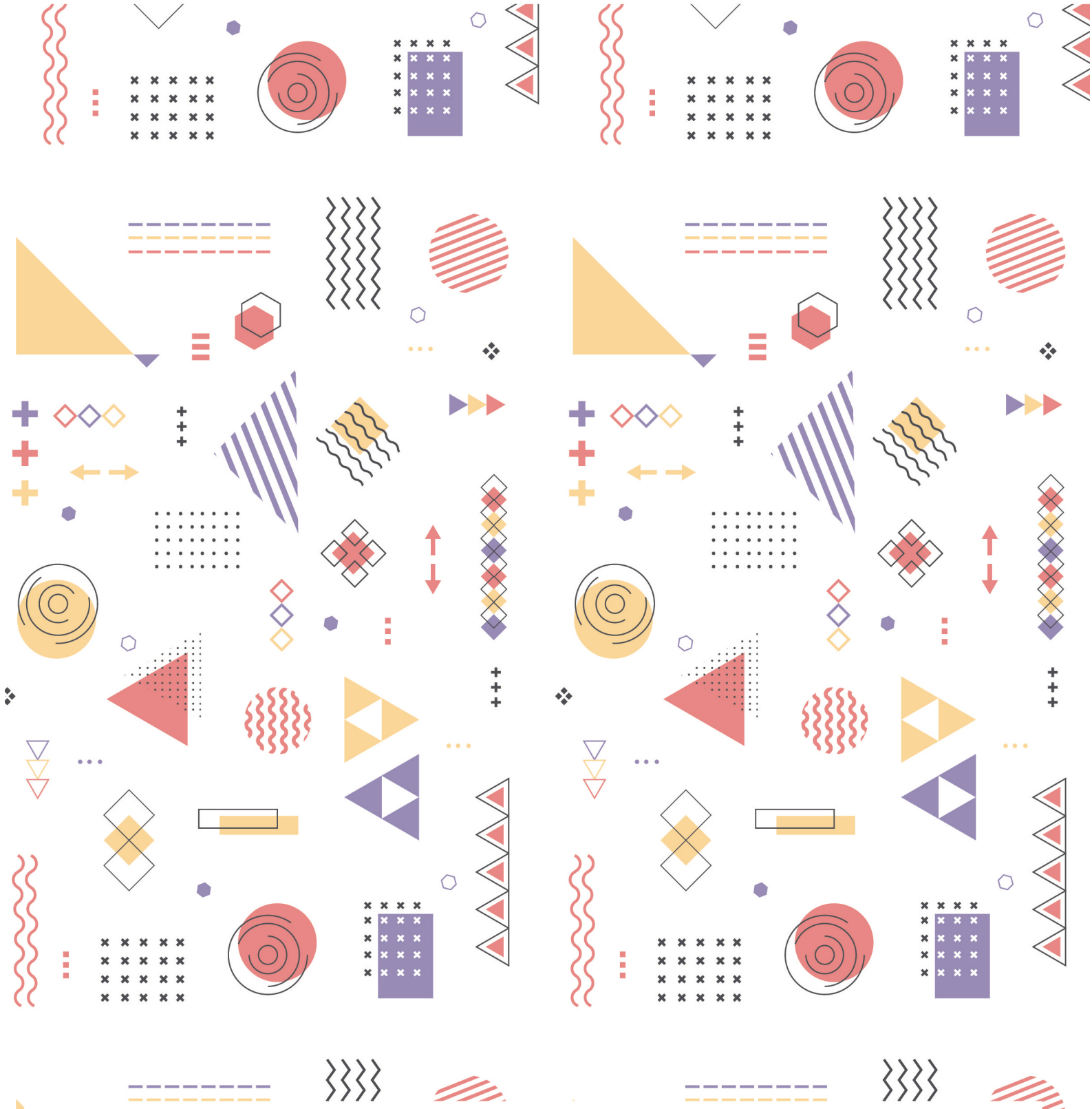
[15] Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, *35*(8), 982–1003.

[16] Pitsikalis, S., Lasica, I.E. & Roussos, I. (2020) Apprenticeship in Greece: focusing on e-learning of a blended learning approach for training vet teachers and trainers in Proc. of *12th annual International Conference on Education and New Learning Technologies (EDULEARN)*, Palma de Mallorca (Spain)., 2012-2018.

[17] Fernández-Caramés, T. & Fraga-Lamas, P. (2020) Use Case Based Blended Teaching of IIoT Cybersecurity in the Industry 4.0 Era. *Applied Science Journal*, 10*,* 5607.

[18] Stein, J. & Graham, C.R., (2020) Examples of blended learning, B*ook Essentials for Blended Learning,* 2nd Edition. ISBN9781351043991

[19] Canavate-Cruzado, G., Moreno-Muro, F.J. & Bueno-Delgado, M.V. (2020), Modernizing the Vocational Educational Training in the field Social Sciences and Humanities towards the Key Enabling technologies in the Digital Transformation, in Proc. of *12th annual International Conference on Education and New Learning Technologies* (EDULEARN), Palma de Mallorca (Spain).



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