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strENgtHening skills and training expertise for TunisiAN and MorocCan transition to industry 4.0 Era / ENHANCE

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Executive Summary

The purpose of 1.3 is to develop the MPQ4.0 learning framework (LF-MPQ4.0). In order to overcome the gap between targeted MPQ4.0 techniques and teachers' knowledge of MPQ4.0. The Learning Framework (LF) will be elaborated with given objectives, clear results, and activities.

This document initially introduces the topic, explains its relevance to the project, and outlines the main points. A literature review is then conducted to gain an understanding of the existing research and debates relevant to the topic. The literature review not only helps us to identify inconstancies (e.g., gaps in research, conflicts in previous studies, open questions left from other research) but also assists to build the LF on existing knowledge. Having provided the foundation of knowledge on the topic, the evaluation/governance process is proposed to guide the way of designing, evaluating, and developing the LF. The evaluation/governance process consists of three main phases (specification, implementation, and exploration) and 8 associated steps. The first phase (specification) and related steps (1 to 6) are presented in this document, addressing the main issues, considerations, evaluations, analyses, and results gained.

Afterward, the LF is proposed, standing on the research, practices, discussions, and analyses performed over this work. The LF contains various useful components and multiple transactions, indenting to provide effective and appropriate services for target users. The concluding remarks are pointed out at the end.

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1. Introduction

ENHANCE – strENgtHening skills and training expertise for TunisiAN and MorocCan transition to industry 4.0 Era – is an Erasmus Plus project founded under the KA2 Cooperation for innovation and the exchange of good practices (Capacity Building in the field of Higher Education) programme by the European Commission under Grant Agreement N° 619130, to be conducted in the period January 2021 until January 2024. It engages 7 partners from 5 countries with a total budget of 779k€. Further information can be found at http://eplus-enhance.eu/.

The emergence of industry 4.0 concepts and applications brings new paradigms impacting all the industrial business domains when they need to conduct successful digital transformations or increase workshops connectivity. The evolution of Maintenance, Production and Quality Engineering (MPQ 4.0) represents the main application domains where Industry 4.0 produces effective beneficial results.

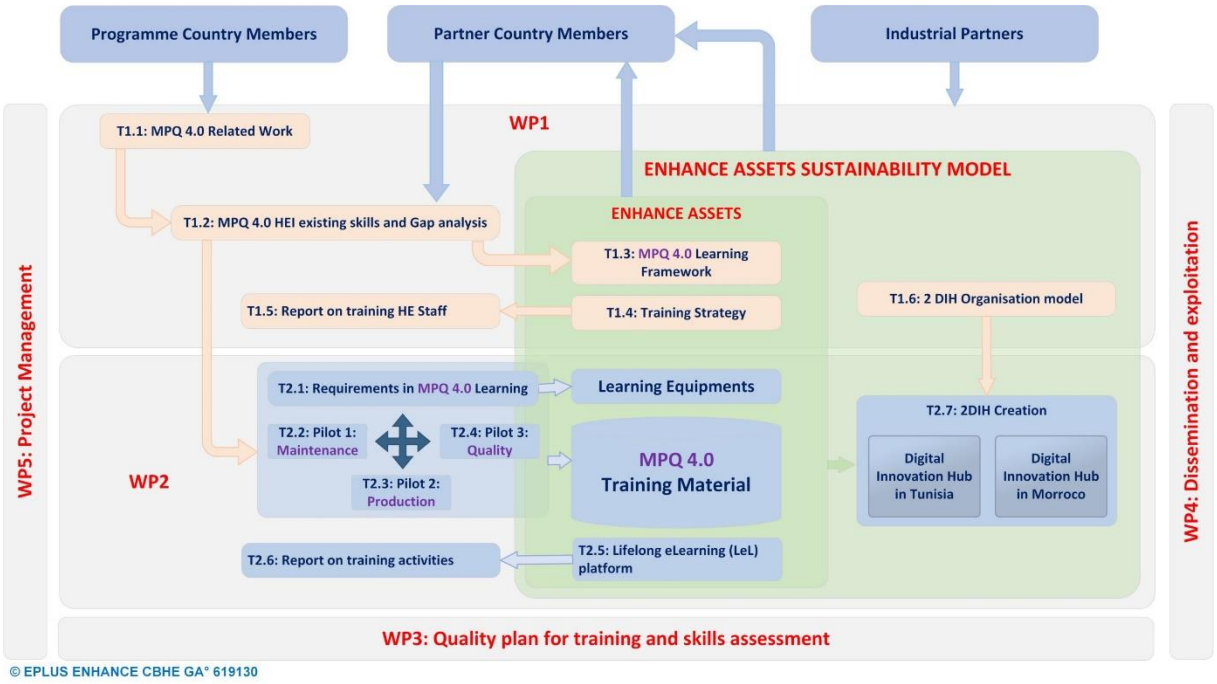


Figure 1. ENHANCE project organization.

The ENHANCE project focuses on building new MPQ training capacities at Higher Education Institutions (HEI) in Tunisia and Morocco to establish interactions between the following stakeholders (figure 1):

- European universities and research institutions (from France, Germany and Portugal) confirmed MPQ 4.0 competencies, training materials, collaborative research projects, full operational Digital Innovation Hubs (DIH), technology transfer experiences, etc.
- Partner country universities (from Tunisia and Morocco) with teaching and training activities in MPQ and existing connections with their local industrial partners.

The ENHANCE project will create several outputs and two primary tangible outcomes:

- New MPQ 4.0 equipment and training materials developed in connection with the existing training programmes and consolidated through three industrial pilots. The new material will be used to train the trainers and the students in the different partner country universities.
- Two DIHs, one in Tunisia and one in Morocco to sustain the project outcomes through their reuse for training in industry.

ENHANCE aims to become the reference model for creating effective and sustainable training material for MPQ 4.0 in both partner countries with content approved by academia and industry.

1.1 Purpose of document

The purpose of the document is to develop the MPQ4.0 learning framework (LF-MPQ4.0). In order to overcome the gap between targeted MPQ4.0 techniques and teachers' knowledge on MPQ4.0. The LF will be elaborated with given objectives, clear results, and activities.

1.2 Applicability

This document presents the way in which the LF is designed, evaluated, and proposed. This document intends to give an overview of potential applicability and appropriateness of proposed LF to the ENHANCE project.

1.3 Definitions

In the following, the main concepts used in this document are briefly explained:

- *Knowledge* – "is central to any discussion of learning and may be understood as the way in which individuals and societies apply meaning to experience. It can therefore be seen broadly as the information, understanding, skills, values and attitudes acquired through learning. As such, knowledge is linked inextricably to the cultural, social, environmental and institutional contexts in which it is created and reproduced" [1].
- *Skill* – "a bundle of knowledge, attributes and capacities that can be learnt and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning" [2].
- *Competencies* – "refers to the application of knowledge, skills, and attitude required to complete a work activity in a range of context and environment to the standard expected in the workplace" [3].
- *Training* – "is the process and methods which aim to equip people with the Skills, attitudes and knowledge needed for employment" [4].
- *Learning* – "is the individual acquisition or modification of information, knowledge, understanding, attitudes, values, skills, competencies or behaviors through experience, practice, study or instruction" [5].
- *Industry 4.0* – is the ongoing automation of traditional manufacturing and industrial practices, using data exchange and modern smart technologies (e.g., IoT, cloud computing, cyber-physical systems, and cognitive computing) to improve companies' operation, products, and services [6].
- *Digital transformations* – in the process of integrating digital technologies into all areas of a business. Digital transformation transforms traditional and non-digital business processes and services or creating new ones, to meet changing business and market requirements [7].
- *Maintenance engineering* – is the discipline and profession of applying techniques and engineering skills (e.g., checking, repairing and servicing machinery, equipment, systems and infrastructures) for the optimization of equipment, processes, and procedures [8].
- *Production engineering* – is the discipline of using machines, tools, materials, and human resources and also creating safe and efficient processes for transforming raw materials into high-quality products [9].
- *Quality engineering* – is a discipline of engineering concerned with the assurance of the overall quality of the manufactured products and delivered service [10].

- *Higher Education Institution* – "a legal entity that offers at least one program leading to a higher education credential" [11].
- *Stakeholder* – "a person or organization with an interest or concern in something. In vocational education and training stakeholders include government, providers of training, industry, clients and the community" [12].
- *Digital Innovation Hub* – is an ecosystem consisting of governments, industry associations, large companies, SMEs (Small and Medium size Enterprises), start-ups, investors, corporations, extension agencies, accelerators, incubators, and research organizations that form a one-stop-shop to best serve their clients within the local region and beyond in order help them to digitalize their functions [13].

1.4 List of acronyms

- DIH – Digital Innovation Hub
- LF – Learning Framework
- LeL – Long life eLearning
- LeL – Long life eLearning
- LRS – Learning Record Storage
- MCL – Mass Collaborative Learning
- MPQ – Maintenance Production Quality
- SMEs – Small and Medium size Enterprises

2. Background

Learning frameworks are research-informed models for course design that help instructors align learning goals with classroom activities, create motivating and inclusive environments, and integrate assessment into learning. learning frameworks provide scaffolded, diverse approaches that help students form knowledge structures that are accurately and meaningfully organized while informing when and how to apply the skills and knowledge they learn. LF focuses on structures for continual student development, inviting students to be “co-producers” in the classroom.

Additionally, LF can provide the architecture and foundation in learning environment for purpose of interaction, communication, and collaboration in different ways such as exchanging the knowledge, techniques, skills, experiences, and/or services) between community members including service providers universities, companies, teachers, and students who interact over the platform. It’s imperative to understand that the community itself is an essential piece of the LF and without that community, the framework has very little inherent value. The LF leverages the community to provide enhanced value to involved members within the ecosystem. The LF allows members (particularly teachers and students) to get the most out of the available resources such as learning materials and techniques. Once the LF built, it can be then accessed by current and new members again and again. The target users that are going to benefits the proposed LF could build up a community at a mass level. Therefore, the LF is proposed to be used in mass collaborative learning.

2.1 Mass collaborative learning

Mass collaboration learning (MCL) is a collective process that takes place when a large enough number of distributed learners work together or in parallel on a single project and share their resources and commonalities to solve a complex problem (related to learning practices) that is often considered insoluble and/or is beyond one's ability and that needs the confluence of different contributions from a variety of backgrounds. Such collaboration is typically mediated by the contents or objects being

created and occurs mostly over the Internet, using social software and computer-supported collaboration tools.

2.2 Identifying the main components and features of the learning framework

To identify the main components and features needed for building LF, the nature, structure, and features of 15 representative examples of MCL community are reviewed, aiming to get inspiration of their ideas and experiences. These successful examples are listed in Table 1.

Table 1: 15 Representative examples of mass collaboration and their positive and negative features.

15 examples of mass collaborative community	
1)	***Wikipedia*** – is a web-based, free-content encyclopedia used as an open collaboration project developed by a very large (open) community of volunteer editors.
2)	***Digg*** – is a social networking and news aggregating website. Contributors submit their stories for consideration and promotion, and they are either voted to be digged, or buried.
3)	***Yahoo! Answers*** – is a question-and-answer website driven by a community in which participants can ask and/or answer questions about anything.
4)	***SETI@home*** – is an Internet-based public volunteer computing project which intends to evaluate radio signals, searching for signs of extra-terrestrial intelligence.
5)	***Scratch*** – is a block-based visual programming language and online community which enables participants to build and share their stories, games, animations, and music on the web.
6)	***Galaxyzoo*** – is a crowd sourced astronomy project that classifies the morphology of large numbers of galaxies through co-operation of interested participants.
7)	***Foldit*** – is an online puzzle video game about protein folding. It invites people to fold the structures of selected proteins (cancer) by using tools provided in the game.
8)	***Applications of the Delphi method*** – the Delphi method or Delphi technique is a structured communication technique or method (it is not a platform) originally developed as a systematic, interactive forecasting method which relies on a panel of experts. Experts respond to several rounds of questionnaires, and the responses are aggregated and shared with the group after each round to gain group consensus.
9)	***Climate Colab*** – is an online crowdsourcing platform that invites people to address global climate changes.
10)	***Assignment Zero*** – is an experiment in crowd-sourced journalism in which participants collectively produce a piece of work.
11)	***DonationCoder*** – is a website hosting a community of programmers and software fans that collectively organize and finance software development.
12)	***Experts Exchange*** – is a trusted global online community that tries to solve the world's technology problems.
13)	***Waze*** – is a community-driven GPS and navigational app that provides navigation information, route details, and travel times.
14)	***Makerspaces*** – is a collaborative workspace where people can come together to use tools for exploring, making, sharing, learning, and and/or completing a project.
15)	***SAP community network*** – is an open, online, and collaborative community of software users, developers, consultants, mentors and students who use the Network to get help, share ideas, learn, innovate and connect with others.

Having reviewed the above-mentioned examples, a number of positive and negative components, features, and factors in each example are identified and selected (see Table 3) that might be used in building and developing the LF. The considered components, features, and factors refer to those

constituent parts and related elements of the application, functional system, or services provided by the system/example. The components, features, and factors that are considered positive can be potentially used in creating and developing the LF. The ones that are considered negative raise a warning alarm or signal about the matter that might be undesirable or harmful for the LF, platform, and/or users. The identified and selected items (components, features, and factors) are classified under 11 proposed dimensions of collaboration, aiming at facilitating their presentation, evaluation, and interpretation (see Table 2).

Table 2: 11 considered dimensions of collaboration.

11 considered dimensions of collaboration
Organizational dimension – is related to the organization of hub or the way it is set up. It is also deals with the action to be performed in the hub. In the context of LF, hub refers to the learning networked environment that brings together the partners and stakeholders of the project (e.g., European universities, research institutions, and partner country universities) and enable them to collaborate with each other toward reaching the common goals.
Environmental dimension – is related to the hub's surrounding environments and also the impact of participants' activities on their condition***.***
Behavioral dimension – is related to the principles, policies, and governance rules that drive the behavior of the hub***.***
Admission dimension – is related to the process of entering or being allowed to enter the hub.
Structural dimension – is related to the hub structure such as participants, relationships, roles, and hub typology.
Social dimension – is related to the collaborative activities and interactions between the participants and hubs***.***
Functional dimension – is related to the base functions, operations, running, and procedures in the hub.
Economical dimension – is related to the supportive and profitable services that can be provided internally or externally.
Technological dimension – is related to using technical means and interconnected components.
Learning assessment – measures the basic knowledge, techniques, skills, and experiences gained by teachers and students.
Performance assessment – measures how well teachers and students apply the acquired knowledge, techniques, skills, and experiences in teaching and learning practices.

3. Evaluation process

To evaluate (a) the usefulness of the selected components, features, and factors in building the LF, and (b) productivity of LF functions, an evaluation/governance process is proposed, helping to critically evaluate the selected components, features, and factors and system functions in collaboration with other partners and stakeholders of the project. The evaluation/governance process is depicted in Figure 2.

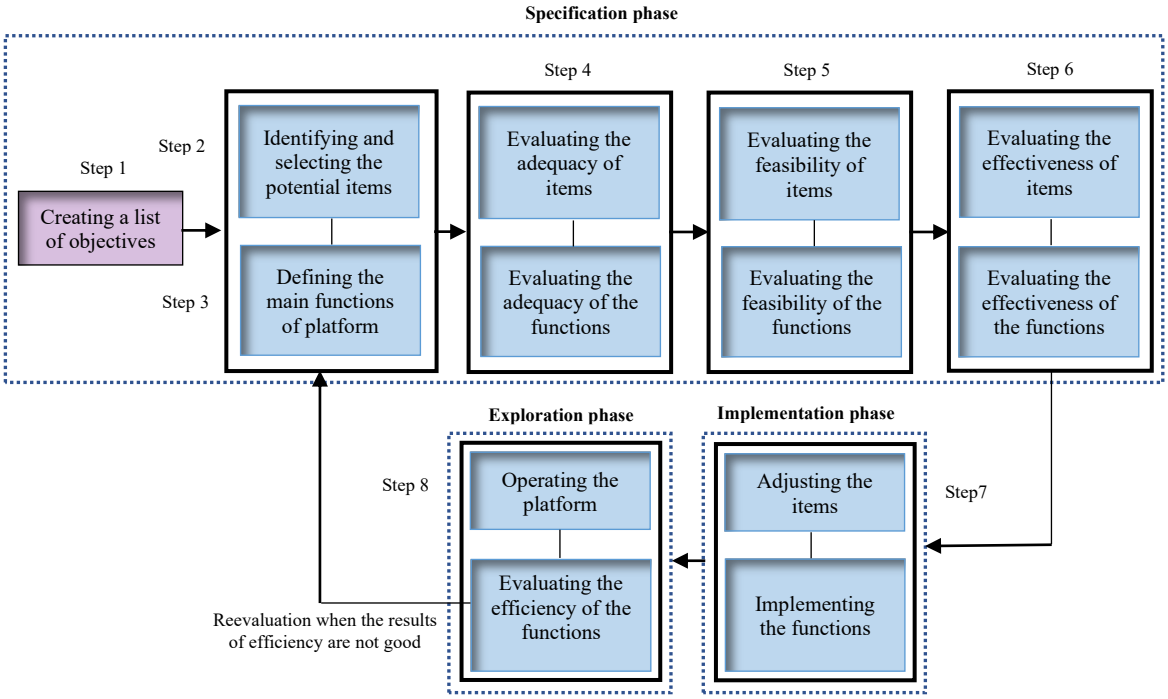


Figure 2: Proposed evaluation/governance process for assessing the selected items.

As illustrated in Figure 2, the evaluation process consists of 3 phases (specification, implementation, and exploration) and 8 respective steps that are briefly explained in the following:

- Specification phase: encompasses steps 1 to 6. It refers to process of identification, selection, and documentation of objectives, dimensions, and requirements to be used in LF.
  - *Step 1 - Specifying project objectives*: these objectives (e.g., creating a Lifelong eLearning (LeL) platform for practitioners and addressing MPQ4.0 skills) clarify the specific and actionable targets that need to be achieved by LF within the time frame of learning practice.
  - *Step 2 – Identifying and selecting the potential components, features, and factors that can be used in building the LF*: the selected components, features, and factors are acquired from reviewing and analysing the examples listed in Table 1. These items are also represented by a number of questions addressed in Table 4.
  - *Step 3 - Determining the main functions of LF*: the functions refer to action executions and transactions in the framework. Considering the objectives and requirements of project, 5 functions for LF are initially proposed to provide a clear vision of the activities that should be performed in relation to the defined objectives. Steps 2 and 3 are performed in parallel.
  - *Step 4 - Evaluating the adequacy of both (a) the selected components, features, and factors as well as (b) the determined functions*: this step first evaluates whether or not the selected components, features, and factors are enough reasonable and adequate to be used in the LF. This task was performed by using an instrument (questionnaire) shown in Table 4. Next, the 5 functions were collaboratively evaluated to find the ones that can adequately meet the objectives.
  - *Step 5- Evaluating the feasibility of both (a) the selected components, features, and factors as well as (b) the determined functions*: the first part of this step of evaluation aims to uncover the strengths and weaknesses of the selected components, features, and factors rationally and objectively in the real environment. The feasibility will be benchmarked by considering the technical capabilities and the available budget in the project. The second part of evaluation

deals with developing the explanation of the functions form feasibility point of view, adjusting the number of functions, and reflecting the functions in the questionnaire used in this step. These tasks were performed by means of second questionnaire presented in Table 10.

- *Step 6 - Evaluating the effectiveness of both (a) the selected components, features, and factors as well as (b) the determined functions*: this step first evaluates the effectiveness of selected components, features, and factors aiming at reducing the number of wasted resources that are used to develop the LF and reach the desired results. Then after, through a group discussion the partners made decision about the effectiveness of functions.

➢ Implementation phase: focuses on step 7. It deals with desirable changes and justifications to be made on selected items as well as realization, designing, and application of system/LF functions and services.

- *Step 7 – Adjusting the selected components, features, and factors and implementing LF functions*: after making all required changes that lead to LF design and improvement, its functions should be appropriately adjusted, adapted and then implemented to make the services available for users.

➢ Exploration phase: includes the last step of evaluation/governance process. It takes care of system/LF operation and function and also its efficient performance.

- *Step 8 – Operating LF and evaluating the efficiency of LF functions*: when the LF starts operation for a certain period, its efficiency should be then evaluated to ensure that it provides efficient services.

3.1 Evaluation steps

With the intention to start the evaluation of considered items and functions for the LF, the first 6 steps of evaluation (in specification phase) were practically and collaboratively performed. In the following, these steps are presented.

3.1.1 Specifying LF objectives (step 1)

The following 3 main objectives are specified to help the setting of the goals in a way that all project activities lead to one single direction:

- *Training Activities* – refer to defining the plans, programs, official drills, exercises, live missions, or other such activities that could improve students' qualifications, knowledge or expertise.
- *Competencies Assessment* – intends to assess students' strengths and weaknesses against the requirements of their studies and future jobs.
- *Training Curriculum Improvement* – focuses on creating, improving, and organizing the course taught the universities. It deals with what will be taught, who will be taught, and how it will be taught.

3.1.2 Identifying and selecting the potential components, features, and factors (Step 2)

As mentioned above, to identify and select the potential components, features, and factors (which could be used in LF generically associated to those main objectives), the structures and features of 15 cases of Mass Collaboration (MC) (from different contexts) are reviewed, analyzed, and then summarized in Table 3. Afterward, the selected items are addressed in the adequacy questionnaire (Table 4).

Table 3: 15 Representative examples of mass collaboration and their positive and negative features.

15 Examples of MC and their features	
1. Wikipedia	
➢ ***Positive Factors***	➢ ***Negative Factors***
• Free, contributed by volunteers • Open access • Easy inclusion, anyone can participate • Users can play different roles and do different tasks • No power hierarchy, users are treated equally • Articles are continuously developed, updated and checked • Consensus can be reached through friendly and open discussion	• Wikipedia editors are anonymous • Quantity or frequency of contributions is not controlled • Not all contents are accurate; the scientific level of articles varies • Contents are not free from bias • Anyone can vandalize the articles • Some users might have fake credentials
2. Digg	
➢ ***Positive Factors***	➢ ***Negative Factors***
• A user-driven website, open to anybody • Easy inclusion • Log in is mandatory, users need to create a Digg user account • Users are volunteers and can play different roles and participate in different tasks • Users can add friends and develop their relationships • Users' information and contributions are associated to their Digg profile • Stories are classified into different groups based on topics • Good stories will be promoted • Contents are checked by the system • Digg raises capital from investors	• There is no editorial control on submissions • Influential group of users can affect the information credibility, promotions, burying, and votes • Users cannot share their opinions because Digg lacks commenting features on the website
3. Yahoo! Answers	
➢ ***Positive Factors***	➢ ***Negative Factors***
• Yahoo! Answers was an open learning community, available in 12 languages, and open to all • Users could connect, share info, add comments, ask questions, answer others' questions and/or vote • There were some categories with multiple sub-categories for organizing the questions • There were "Point System" and "Voting System", • Users could receive a "badge" under their name, e.g., naming them as a "Top Contributor" • Staff could reach different levels of authority and site access • Supportive users were featured on the Yahoo! Answers Blog • The "user moderation system" handled its misuses • Posts could be detached if they received a sufficient negative weight • Supported by funds and financial aides • Provided diverse supportive services	• Users could use any name and photo for opening the account • There was no system to filter the incorrect answers • There were improper grammar and incorrect spelling in answers • Once the "best answer" was chosen, there was no chance to add more answers nor improvement
4. SETI@home	
➢ ***Positive Factors***	➢ ***Negative Factors***
• Open to anybody • Easy inclusion • Participants are volunteers and can build a team and make competitions • Has a "Voting System" to determine the validity of the results • The "Credit System" monitors how much work is done • It raises financial donations	• The risk of cheating (for gaining credit) is high • Some participants might misuse the resources of the projects to gain work-unit results • The projects do not share their resources
5. Scratch	
➢ ***Positive Factors***	➢ ***Negative Factors***
• Open to anybody and available in 70+ languages • It can be used in different settings: schools, libraries, community centers, museums, and homes • Users can ask questions, share their creative ideas, stories, and projects, get feedback, and collaborate with others • If something breaks the community's rules, Scratch will take respective action (e.g., sends a warning to the account, removes it, or blocks the account)	• Without creating an account, users can contribute (e.g., create their own projects, read and put comments) • Users can create several accounts

6. Galaxy Zoo	
➢ ***Positive Factors***	➢ ***Negative Factors***
• Easy inclusion • Users are volunteer • Creating user account is necessary • Username is associated to user's contributions • It uses computer technologies and human intelligence for classification of galaxies • It monitors and analyses some of the contributions and transactions • Information is stored in a secured database • It uses "Amazon Web Services" to rapidly serve the website to a large number of people • It raises funds	• Using the real name is not a must for registration • Personal information cannot be completely removed from the system • The classification system cannot provide feedback about the process of classification
7. Foldit	
➢ ***Positive Factors***	➢ ***Negative Factors***
• Open to all • Easy inclusion, engaging the general public and scientific teams in online research • Players can use Foldit forum for collaborations e.g., train new players • It relies on human-computer interaction • It has a "Ranking" and "Awarding System" • The website records, monitors, and stores the posts and interactions • It publishes all important scientific discoveries • The results can be used in scientific publications • It benefits from grants	• Players can play without an account, so there are many anonymous identifiers in the community • It is not easy to learn and play Foldit • Playing Foldit needs a decent computer
8. Applications of the Delphi method	
➢ ***Positive Factors***	➢ ***Negative Factors***
• There are different types of Delphi • Each panel will be selected and invited • The experts can discuss about or comment on others' forecasts • All the experts and their forecasts are giving equal weight • It can be applied in the several different fields of science • It can raise funds	• The potential experts might not agree or be available for participation • The method is not able to make complex forecasts with multiple factors • The response times might take several days
9. Climate Colab	
➢ ***Positive Factors***	➢ ***Negative Factors***
• Benefits from contribution of experts and crowds • Easy inclusion • Users are volunteers and can play different roles and perform different tasks • Users can collaborate on the platform with whoever is interested in similar topics • Users can comment on others' proposals • It has a "Voting System", "Rewarding System", "Messaging System ", and "expert advisory board" • In the website, there is a list of community members, their points, roles, activities, and membership date • It raises funds and financial supports	• It must continuously identify, invite, and maintain a large number of different expertise • It uses top-down approach in the community
10. Assignment Zero	
➢ ***Positive Factors***	➢ ***Negative Factors***
• Open to all • Users are volunteers • Users must create a user account by providing the real full name and a valid e-mail address • There is a list of tasks that users can perform • Users can contribute to different topics • Users are encouraged to make themselves known to the public by providing their biography • It gives credit to the contributions, and it is supported by founds	• Users might produce and share stories recognized as useless • Interviews often take place face-to-face, so the candidates have to live close to the interviewee
11. DonationCoder	
➢ ***Positive Factors***	➢ ***Negative Factors***
• It provides free tools and services	

• Registration needs a valid email address • There are different forms of communication • All users are considered equal • It benefits from grants and donations	• Users can sign up at the website by using a different email and name • Some sections of the website are available only to donators • For participation in the forum, participants require first donating, and then receiving the license key, registering a forum account, and lastly upgrading their forum account • The contracting and consulting services aren't cheap
12. Experts Exchange	
➢ ***Positive Factors*** • Users must register with accurate email address • Users are not allowed to have more than one account, • Users are volunteers • EE covers over 230 tech topics, and prioritizes the contents based on usefulness • Users can receive recognition and secure credentials with "Credly" (a digital badge platform that provides digital credentials to individuals through working with credible organizations) • EE provides a variety of professional training courses in a wide variety of topics, and it produces various video tutorials	➢ ***Negative Factors*** • EE provides answers only via paid mode • If a user account is past due, EE might cancel his account for non-payment
13. Waze	
➢ ***Positive Factors*** • User-generated community • It is free to download and can be used anywhere • It relies on crowd sourced information • Users need registration • Users can connect and work together • It offers points to users • Advertising is the main source of generating revenue	➢ ***Negative Factors*** • Using Waze needs enough initial and active users to collectively create the local maps and continuously update data to make it useful • Very limited number of countries (13) have a full base map, in others either the map is incomplete, or not yet used • Waze currently supports only private cars, not public transportation, bicycle, or trucks
14. Makerspaces	
➢ ***Positive Factors*** • It is member-driven • It can take different forms (physical, virtual), shapes, sizes, and for different purposes • Most of Makerspaces need registration • Users are people with common interests • Users can meet, socialize, and collaborate (on projects), co-create, learn new skills, share, research, explore and invent, prototype, solve problems, play, and even boost self-confidence • It benefits from funds and financial support	➢ ***Negative Factors*** • Some Makerspaces have membership fees • Physical Makerspaces have been criticized for their high costs associated with tools and materials
15. SAP Community Network	
➢ ***Positive Factors*** SAP community network serves as a resource repository and a platform for SAP users to collaborate with each other • Software users, developers, consultants, mentors and students use the SAP Community Network to get help, share ideas, learn, innovate and connect with others • Open to all • Users are volunteers • It offers/hosts discussion forums, tutorials, expert blogs, sap code sharing gallery, utilities, technical library, wiki, article downloads, e-learning catalogs, and other facilities through which its users contribute their knowledge • It has its own channel on YouTube • Its users' knowledge contribution to the community can be quantified • It has a contributor recognition program (CRP) that awards points to community users for each technical article, code sample, video, wiki contribution, forum post, and weblog authored.	➢ ***Negative Factors*** • Knowledge flows are not measurable • The questions asked before are not easy accessible • It is impossible to read the list of problems in the scope of the theme • There is no control to navigate to the blogs section directly • It is difficult to find the important and most liked blogs

• SAP publicly recognizes its most active contributors • It has over 430 spaces (sub-groups)	

3.1.3 Determining the main functions of LF (Step 3)

To determine the main functions of LF, the specified objective (presented in step 1), requirements, and conditions of the LF were considered, aiming at providing the appropriate services for users of the system. To clarify the internal operation of the system (LF), at the beginning the following 5 functions are collaboratively determined by the project partners and stakeholders:

- *Function 1 (dynamic training design)* – is the function of creating and developing new training and educational courses and lessons for the existing learners (students/employees) taking in consideration learning assessments that would invoke changes in the programme to students better fulfil the learning objectives. The changes in programme are automatically done representing such dynamicity mentioned in the function.
- *Function 2 (training programme generator*) – is the function that generates the training programme accordingly to determined profile characteristics of the student.
- *Function 3 (improving training course contents*) – this function helps to identify distinctive research results (potentially results of DIH activities) that may be used to improve courses contents and from students' behavior (learning evaluation results).
- *Function 4 (training execution support*) – this function provides the needed support for (a) training execution, training planning, and (b) learning engagement strategies.
- *Function 5 (training quality assessment*) – this function provides the needed support for design the overall training performance-based assessment and reporting.

3.1.4 Evaluating the adequacy of selected components, features, and factors (Step 4)

To evaluate the efficacy and adequacy of selected components, features, and factors, several positive factors and specific features (selected from Table 3) that have potential application to LF are picked out and adapted to be then evaluated. The selection of potential components, features, and factor (to be presented in the questionnaire) was initially done by technical team in UNL through considering the desired items (from the list addressed in Table 3) for the platform from the adequacy point of view. Table 4 shows the relationships between the considered (positive and negative) components, features, and factors of Wikipedia and the related questions which are addressed in the questionnaire (Table 5). As an example, the fist positive feature of Wikipedia (free, contributed by volunteers) is represented by questions 16 and 60 in the questionnaire.

Table 4: Relationships between the considered (positive and negative) components, features, and factors of Wikipedia and the related questions which are addressed in the questionnaire (Table 5).

Wikipedia			
➢ ***Positive Factors***	***Related Qs***	➢ ***Negative Factors***	***Related Qs***
• Free, contributed by volunteers	• 16, 60	• Wikipedia editors are anonymous	• 21, 22, 46
• Open access	• 8, 59		
• Easy inclusion, anyone can participate	• 2, 15	• Quantity or frequency of contributions is not controlled	• 39, 82
• Users can play different roles and do different tasks	• 64, 66, 67	• Not all contents are accurate; the scientific level of articles varies	• 35, 81
• No power hierarchy, users are treated equally	• -		
• Articles are continuously developed, updated and checked	• 33, 34	• Contents are not free from bias	• -
		• Anyone can vandalize the articles	• -
• Consensus can be reached through friendly and open discussion	• 43	• Some users might have fake credentials	• 38, 39

To benchmark the adequacy and importance of the selected components, features, and factors, they are addressed in 90 questions or statements, forming the adequacy questionnaire (see Table 5).

Each question or statement in this questionnaire represents a potential components, features, and factors that might be used in LF. The questions or statements - based on the specifications and characteristics that they present- are classified under 11 considered dimensions of collaboration namely, organizational, environmental, admission, behavioural, social, structural, functional, technological, economical, learning assessment, and performance assessment. This classification facilitates the presentation, analyse, and interpretation of the results of evaluation.

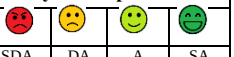
The adequacy and importance of the selected components, features, and factors are asked and assessed by a checklist in the questionnaire. There are six possible answers in the checklist for each question or statement namely, strongly disagree (weight = 1), disagree (weight = 2), agree (weight = 3), strongly agree (weight = 4), not sure (weight = 0), and I don´t know (weight = 0). The evaluators (partners and stakeholders) not only can choose one of these possible answers, but also, they can put comments and feedback (if needed) right after each question or statement. It is noteworthy to mention that this questionnaire provides a kind of general evaluation of considered dimensions and their respective components, features, and factors.

The questionnaire (along with an explanatory text that describes the survey objectives and instruction) was sent to each organization partner of the ENHANCE consortium, and they were asked to respond to the questions or statements collaboratively (with their internal involved members who are experienced in this field of study and work). Therefore, the questions or statements in each questionnaire were answered by the cooperation and confluence of different minds rather than a single partner. This strategy not only helped to reduce the number of questionnaires that were sent, answered, and evaluated, but also increased the quality and accuracy of the given answers. The adequacy questionnaire is presented in Table 5.

Table 5: Questionnaire for evaluating the adequacy of selected components, features, and factors.

Questionnaire for evaluating the adequacy of the considered dimensions of collaboration and their related components, features, and factors that have the potential to be used in LF.		
Considered Dimensions	Components, features, and factors that might be integrated into LF	Checklist
Organizational Dimension - (Relates to the organization of Learning Framework (LF) or the way it is set up. It is also deals with the action to be performed in the LF)	**1)** It is important that even general users (e.g., learners) could help (the partners and administrators) to develop the LeLP.	    SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	2) It is important that the LeLP engages diverse groups of learners (e.g., from different background) in the process of learning.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	3) It is important that the LeLP provides opportunities for collective learning.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	4) It is important that the LeLP could be used for different purposes (e.g., education, tutorials, developing competencies, promoting workforces, R&D).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	5) It is important that the LeLP facilitates the process of knowledge building, sharing, and developing.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	6) It is important that the LeLP could be used for different fields of study and work.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	7) It is important that the LeLP be a user-driven service (users/learners are considered as the main component, contributor, and supporter).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
Environmental Dimension -	**8)** It is important that the LeLP be open for all interested learners to contribute.	    SDA DA A SA I don't know I'm not sure

(Relates to the Learning Framework's surroundings and also the impact of participants' activities on its condition)	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	9) It is important that the LeLP provides three levels of access (for three groups of users: partners, administrators, and general users/learners).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	10) It is important that the LeLP could be available in different languages (e.g., English, French).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	11) It is important that the LeLP facilitates different forms of communication (virtual, physical, or mixed).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	12) It is important that the LeLP provides a common collaboration space to be used by different settings such as educational, industrial, services, and labs.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	13) It is important that the LeLP provides a supportive environment in which users can help each other.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	14) It is important that the LeLP simulates the ways users collaborate toward building a dynamic and active community.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
Admission Dimension - (Relates to the process or fact of entering or being allowed to enter the LF environment of ECP. It includes two main sub-areas: Inclusion (questions from 15 till 20) and Accessibility & Proximity (questions from 21 till 25))	*Inclusion*				
	15) It is important that the LeLP facilitates the process of joining (inclusion) to the community.				
		SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	16) It is important that the LeLP provides free access for all users.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	17) It is important that the LeLP provides a service for identifying and inviting a specific group of participants such as, trainers, experts, technical, and managerial.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	18) It is important that all the users actively take part in introducing the community to potential and interested persons.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	19) It is important that the LeLP suspends or even deactivates a user's account who does not follow the rules.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	20) Users can stop their contribution at any time.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	Accessibility and Proximity				
	21) To promote the quality and reliability of contributions, it is important that the LeLP reduces the anonymity of users.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	22) To reduce anonymity, it is important that the users create a user account and register by providing the real personal information (e.g., full name, profession, and e-mail address, and photo).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	23) It is important that the LeLP incentives the user to actively contribute and keep contribution.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	24) It is important that the LeLP tracks the time-outs (to check if there is problem with users or services).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	25) It is important that the username be associated with the user's contributions (to facilitate monitoring of contributions).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
Social Dimension - (Relates to the collaborative activities and interactions between the participants of the LF)	*Collaboration*				
	26) It is important that the LeLP builds a network for career development.				
		SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	27) It is important that the users could learn new things collaboratively.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	28) It is important that the users could solve the problems collaboratively.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	29) It is important that the LeLP could provide computer-supported collaborative tools for collaboration.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	30) It is important that the LeLP could provide a "discussion forum" for collaboration.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	31) It is important that the users could build interdisciplinary collaboration (a collaboration that engages individuals from different teams, disciplines, and backgrounds).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				

	32) It is important that the LeLP could support building strategic partnerships and alliances with potential external parties (to share the resources and expertise).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
Functional Dimension - (Relates to the base functions, operations, running, and procedures in the LF or ECP. It includes four main sub-areas: Content Management (questions from 33 till 36), Operation Management (questions from 37 till 40), Interaction Management (questions from 41 till 44), and Human Resource Management (questions from 45)) till 49).	*Content Management*	
	33) It is important that the LeLP could make accessible the created and developed content for all users.	 SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	34) It is important that the LeLP could support the process of developing and updating the training contents, when is needed.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	35) It is important that the LeLP could classify the developed contents into specific courses and majors (based on predefined topics).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	36) It is important that the LeLP could save the developed contents in a secured database.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	Operation Management	
	37) It is important that the LeLP could continuously promote/update its operational processes (set of activities or tasks that produces a specific service).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	38) It is important that the LeLP could save users' personal information and contributions in their profile.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	39) It is important that the LeLP could provide a "monitoring system" to constantly monitor the transactions and contributions.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	40) It is important that when someone breaks the rules, LeLP could take the needed actions (e.g., sends a warning message to the account, removes it, or blocks the account).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	Interaction Management	
	41) It is important that the LeLP could provide an appropriate service for internal interactions such as sharing the resources, training, and learning materials.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	42) It is important that the LeLP could provide an appropriate service for external interactions such as exchanging the expertise and findings.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	43) It is important that the LeLP could provide multiple communication channels (e.g., email, live chat, message board, wiki, and social networks).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	44) It is important that the LeLP could provide opportunities for external interactions and collaboration with similar communities.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	Human Resource Management	
	45) The users should be treated equally.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	46) It is important that the LeLP could encourage the users to make themselves known to the public (by providing their background knowledge and expertise).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	47) It is important that the LeLP could provide a consult and advisory board (for each field of study, major, or course).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	48) It is important that the LeLP could retain effective users (for example by giving rank, badge, and more access).	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	49) It is important that the LeLP could use outsourced experts, teachers, and talents.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
Economical Dimension - (Relates to the supportive services that could be provided internally and/or externally)	*Supports and Services*	
	How important do you think the following services could be for the economic sustainability of the platform:	
	50) Benefiting from private and public funding, grants, financial aids and donations, capital from investors and sponsors, and advertising.	 SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	51) Providing supportive training and learning services for schools, organizations, institutions, businesses, and companies.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	52) Providing supportive training, learning, and research services for research centers, living labs, innovators, and etc.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	53) Providing support services for conferences and workshops.	SDA DA A SA I don't know I'm not sure

	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	54) Developing a program that assists and guides the users in making occupational choices.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
Technological Dimension - (Relates to using technical means and interconnected components of the ECP)	**55)** It is important that the LeLP could provide sufficient technologies that support web-based communication and collaboration.				
		SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	56) It is important that the LeLP could use ICT technologies and Computer-Supported Collaborative Learning to support training.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	57) It is important that the LeLP could use potential tools for assessing the performances.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	58) It is important that the LeLP could benefit of external technological supports.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
Structural Dimension - (Relates to the network structure such as participants, relationships, roles, and network typology of the LF. It includes two main sub-areas: Participants (questions from 59-65) and Roles & Tasks (questions from 66 till 70))	*Participants*				
	59) It is important that the users from any age, background, culture, and gender could contribute to LeLP.				
		SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	60) Users will not be paid, and they will contribute on the volunteer base.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	61) It is important that the LeLP provides different/specific services for different/specific groups of users (e.g., learners, trainers, experts, researchers, academics, managers, and entrepreneurs).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	62) It is important that the LeLP could deliver the services for people outside the community.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	63) It is important that the LeLP provides some special services for people with special needs (e.g., people with disabilities).	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	64) It is important that the users could participate in particular activities that are related to their interests and background.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	65) It is important that the LeLP makes available a list of the services that could deliver.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	Roles and Tasks				
	66) It is important that the users could play different roles (e.g., expert, advisor, trainer, trainee, editorial, researcher, technical, managerial) based on their qualifications.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	67) It is important that the users could engage in multiple tasks (e.g., training execution, providing learning contents, delivering the contents, exchanging the contents, executing, providing supports, commenting, reporting) based on their interests and capabilities.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	68) It is important that the users could simultaneously contribute to different domains, courses, majors, practices, issues, and events.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	69) It is important that the users could support the process of training development.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	70) It is important that the users could support the contributions of different people.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
Behavioral Dimension - (Relates to the principles, policies, and governance rules that drive the behavior of the LF)	**71)** Only the partners and administrators have the authority to make structural changes in the LeLP.				
		SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	72) The general users do not have the authority to make technical changes in the LeLP.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	73) The general users can contribute to decision-making processes.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	74) It is important that the governance rules for the community be defined in a collaborative and democratic way.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	75) To build trust, the LeLP must make transparent policies for the community.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	76) It is important that the LeLP perceived ease of use and perceived usefulness.	SDA	DA	A	SA
		I don't know		I'm not sure	
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)				
	77) It is important that the LeLP provides a "feedback system".	SDA	DA	A	SA
		I don't know		I'm not sure	

	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	78) It is important that the LeLP provides a "conflict resolution system".	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
Learning Assessment Dimension - (elates to learners´ qualification, performance, contribution, and output)	**79)** It is important that the LeLP could provide an assessment service for measuring learners´ background knowledge.	 SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	80) It is important that the LeLP could provide an assessment service for measuring trainers´ qualifications.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	81) It is important that the LeLP could provide an assessment service for measuring the quality of training materials.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	82) It is important that the LeLP could provide an assessment service for measuring the contributions.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	83) It is important that the LeLP could provide an assessment service for measuring the knowledge gained by learners.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	84) It is important that the LeLP could provide an assessment service for measuring the success of collaborative learning.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
Performance Assessment Dimension - (Relates to ECP performance evaluation, namely in relation to its related functions or community activities)	**85)** It is important that the LeLP could provide an assessment service for measuring the operation of community.	 SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	86) It is important that the LeLP could provide assessment service for measuring the effectiveness of coordination.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	87) It is important that the LeLP could provide assessment service for measuring the productivity of community.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	88) It is important that the LeLP could provide an assessment service for measuring the effectiveness of used technologies.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	89) It is important that the LeLP could provide an assessment service for measuring the outputs of community.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	
	90) It is important that the LeLP could provide an assessment service for measuring the profitability of community.	SDA DA A SA I don't know I'm not sure
	If you have any suggestions for this issue please feel free to let us know. (you can use this box)	

The main results of adequacy evaluation (percentage of the popularity of considered dimensions and their components, features, and factors that might be integrated into LF) achieved from analyzing the 9 received questionnaires are summarized in Table 6. As presented in Table 6, there is the list of considered dimensions for collaboration, the number of developed questions per dimension, the weighted average (is the average weight given to the questions or statements of each dimension by the evaluators), and the percentage of the popularity of dimensions from the evaluators' point of view. In this step of evaluation, the received responses were automatically analyzed by the applied tool (SurveyMonkey).

Table 6: Main results of adequacy evaluation.

Considered Dimensions	Number of questions per dimension	Weighted average	Percentage of the popularity of dimensions
- Organizational	7	3.50	87.50%
- Environmental	7	3.41	85.25%
- Admission	11	3.15	78.75%
- Social	7	3.49	87.25%
- Functional	17	3.50	87.50%
- Economical	5	3.48	87%
- Technological	4	3.63	90.75%
- Structural	12	2.46	61.50%
- Behavioral	8	3.85	96.25%
- Learning	6	3.68	92%
- Performance	6	3.13	78.25%

To have a better view of the results of this step of evaluation, they are also displayed in an illustration in Figure 3.

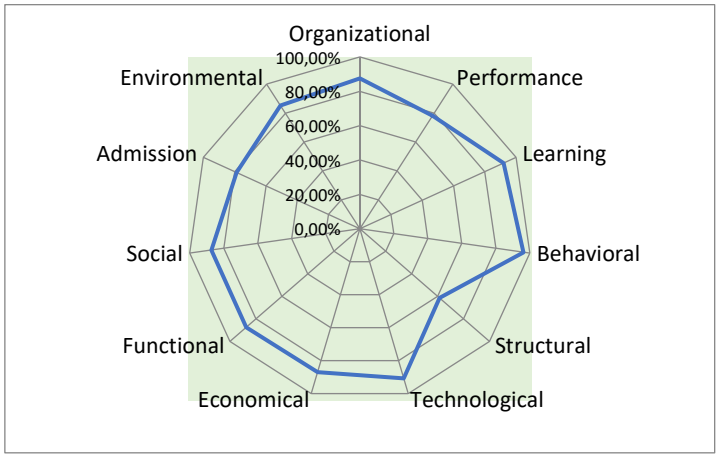


Figure 3: Percentage of popularity of dimensions in adequacy evaluation.

Considering the given responses to questions of adequacy questionnaire, and from the performed analysis it can be concluded that:

- All the considered dimensions are generally accepted by all evaluators (partners). Because the average popularity given to all dimensions is above 50% (an indicator of acceptance).
- Among the considered dimensions, the behavioural dimension and its respective components, features, and factors received the highest average of popularity (96.25%). Whereas the structural dimension received the lowest average of popularity (61.50%) from the respondents' point of view.
- Among the addressed component, feature, and factor in each dimension, those that have the highest percentage of popularity are selected for further evaluation (see Table 7).

Table 7: Selected components, features, and factors in each dimension for further evaluation.

Dimensions	**Questions and considered components, features, and factors**	weighted average (out of 4)
Organizational	Q1. It is important that the ECP be used for different purposes (e.g., education, tutorials, developing competencies, promoting workforces, R&D)	3.67
	Q2. It is important that the ECP facilitates the process of knowledge building, sharing, and developing	3.78
Environmental	Q3. It is important that the ECP could be available in different languages (e.g., English, French)	3.56
	Q4. It is important that the ECP provides a common collaboration space to be used by different settings such as educational, industrial, services, and labs	3.67
Admission	Q5. It is important that the ECP provides a service for identifying and inviting a specific group of participants such as, trainers, experts, technical, and managerial	3.67
	Q6. It is important that the ECP suspends or even deactivates a user's account who does not follow the rules	3.67
	Q7. To promote the quality and reliability of contributions, it is important that the ECP reduces the anonymity of users	3.56

Social	Q8. It is important that the ECP could provide computer-supported collaborative tools for collaboration	3.63
	Q9. It is important that the ECP could provide a "discussion forum" for collaboration	3.67
Functional	Q10. It is important that the ECP could classify the developed contents into specific courses and majors (based on predefined topics)	3.89
	Q11. It is important that the ECP could save the developed contents in a secured database	3.89
	Q12. It is important that the ECP could provide an appropriate service for internal interactions such as sharing the resources, training, and learning materials	3.78
Economical	Q13. Providing supportive training and learning services for schools, organizations, institutions, businesses, and companies	3.78
	Q14. Providing supportive training, learning, and research services for research centers, living labs, innovators, and etc	3.56
Technological	Q15. It is important that the ECP could provide sufficient technologies that support web-based communication and collaboration	3.67
	Q16. It is important that the ECP could use potential tools for assessing the performances	3.88
Structural	Q17. It is important that the users could participate in particular activities that are related to their interests and background	3.56
	Q18. It is important that the users could simultaneously contribute in different domains, courses, majors, practices, issues, and events	3.56
Behavioral	Q19. Only the partners and administrators have the authority to bring about structural changes in the ECP	3.78
	Q20. The general users do not have the authority to make technical changes in the ECP	3.67
	Q21. To build trust, the ECP must make transparency of community policies	3.89
	Q22. It is important that the ECP provides "feedback system"	3.67
Learning	Q23. It is important that the ECP could provide assessment service for measuring trainers´ qualification	3.89
	Q24. It is important that the ECP could provide an assessment service for measuring the quality of training material	3.78
	Q25. It is important that the ECP could provide an assessment service for measuring the knowledge gained by learners	3.78
Performance	Q26. It is important that the ECP could provide an assessment service for measuring the operation the of community	3.22
	Q27. It is important that the ECP could provide assessment service for measuring the outputs of the community	3.22

3.1.5 Evaluating the adequacy of LF functions (Step 4)

After evaluating the adequacy of selected components, features, and factors, the defined functions for the LF are also evaluated collaboratively. The evaluation focuses on judging whether or not the functions can adequately meet the objectives of project. Thus, in a theoretical and conceptual evaluation, the functions that show signs of adequacy for meeting one or some project objectives are addressed with (X) in Table 8.

Table 8: Evaluating the adequacy of LF functions.

ENHANCE Main Processes	
LF Functions	Project Objectives

	Training activities	Competencies assessment	Training curriculum improvement
F1. Dynamic training design	x	x	
F2. Training programme generator	x		
F3. Improving training course contents		x	x
F4. Training execution support	x		
F5. Training quality assessment		x	x

3.1.6 Evaluating the feasibility of selected components, features, and factors (Step 5)

The feasibility of the selected components, features, and factors are evaluated by the technical team (in UNL). The technical team by considering the results of adequacy evaluation (presented in Table 6) and also the available resources (e.g., budget, time, capabilities) attempted to:

- Assess the possibility, workability, and expediency of the selected components, features, and factors to be used in LF and applied on the platform.
- Assess the association, connection, and relevancy of the selected components, features, and factors to the addressed LF functions.
- Categorize the selected components, features, and factors under-addressed LF functions.

Through performing this task and assessing the considered selected components, features, and factors, the technical team came to this conclusion that the number of LF functions should be increased to properly address and classify the required features and capabilities. Thus, four new/general functions for LF are proposed including:

- *Function 6 (user identification and invitation)* – this function is for identifying and inviting the specific/demanding participants such as trainers, experts, technical, and administrative.
- *Function 7 (user's account management e.g., activation, deactivation)* – this function is for managing accounts by providing different access rights or profiles and facilitating activation/deactivation of accounts.
- *Function 8 (communication by means of "discussion forum")* – this function provides a message and discussion boards for asynchronous communication among users.
- Function 9 (managing internal interactions and transactions) – this function helps managing various interactions and transactions between users e.g., sharing the resources and training/learning materials.

Considering Table 7, the results of the feasibility evaluation are presented in Table 9.

Table 9: Results of evaluating the feasibility of the selected components, features, and factors.

Functions	Organizational		Environmental		Admission			Social		Functional			Economical		Technological		Structural		Behavioral				Learning			Performance	
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27
F1																											
F2																											
F3																											
F4																											
F5																											
F6																											
F7																											
F8																											
F9																											

Feasible Not feasible

As it is shown in Table 9, for covering the components, features, and factors addressed in each question (presented in Table 7), one or some functions might contribute. For example, for covering the addressed components, features, and factors in question 1, the first 5 functions should make a contribution. It is notetaking that the components, features, and factors pointed out in questions 19 and 20 are not feasible (from technical partners' point of view) to be used in LF and the digital platform.

3.1.7 Evaluating the feasibility of LF functions (Step 5)

In order to evaluate the feasibility of LF functions, the technical partners proceed with function specification, adjustment, and improvement. For doing so, by taking into account the results of the adequacy evaluation presented in Table 7, the objectives of the project, and also the requirements of the LF and Platform, the technical team came up with a questionnaire to collect the opinion of other partners. In this primary version of the questionnaire, the 9 proposed LF functions with their respective questions are presented, addressing the potential features and capabilities to be considered (see Table 10).

Table 10: First version of questionnaire considered for evaluating the feasibility of LF functions.

Questionnaire	
Function 1 *(dynamic training design)* – is the function of creating and developing new training and educational courses and lessons for the existing students/employees taking into consideration learning assessments that would invoke changes in the programme to students better fulfill the learning objectives.	
1 (from the definition)	It should create and develop new training and educational courses and lessons for the existing students/employees.
2 (from the definition)	It should take into consideration the learning assessments that invoke changes in the programme (which help students better fulfill the learning objectives).
3 (from Q1 of Table 6)	The training design should be used for different purposes (e.g., education, tutorials, developing competencies, promoting workforces, R&D).
4 (from Q3 of Table 6)	The training design could be available in different languages (e.g., English, French).
5 (from Q7 of Table 6)	The training design should be used by recognized users (who are not anonymous).
6 (from Q8 of Table 6)	The training design could benefit of computer-supported collaborative tools.
7 (from Q10 of Table 6)	The training design should be used for creating specific courses and majors (based on predefined topics).

8 (from Q11 of Table 6)	The training design should benefit of the advantages of a secured database.
9 (from Q13 of Table 6)	The training design should be used in training and learning services for different schools, organizations, institutions, businesses, and companies.
10 (from Q14 of Table 6)	The training design should be used in training and learning services for different research centers, living labs, innovators, etc.
11 (from Q15 of Table 6)	The training design could benefit from supportive technologies e.g., web-based communication and collaboration.
12 (from Q21 of Table 6)	The training design should take into account the trust and transparency principles and policies of the community.
13 (from Q22 of Table 6)	The dynamic training design could benefit of using the "feedback system".
Function 2 *(training programme generator)* – is the function that generates the training programme accordingly to determine profile characteristics of the student.	
14 (from the definition)	The training programme generator should take into account the determined profile characteristics of student.
15 (from Q1 of Table 6)	The training programme generator should be used for different purposes (e.g., education, tutorials, developing competencies, promoting workforces, R&D).
16 (from Q3 of Table 6)	The training programme generator should be available in different languages (e.g., English, French).
17 (from Q7 of Table 6)	The training programme generator should be used by recognized users (who are not anonymous).
18 (from Q11 of Table 6)	The training programme generator should benefit of a secured database.
19 (from Q13 of Table 6)	The training programme generator should be used in training and learning services for different schools, organizations, institutions, businesses, and companies.
20 (from Q14 of Table 6)	The training programme generator should be used in training and learning services for different research centers, living labs, innovators, etc.
21 (from Q15 of Table 6)	The training programme generator could be supported by assistive technologies e.g., web-based communication and collaboration.
22 (from Q21 of Table 6)	The training programme generator should consider the trust and transparency principles and policies of the community.
23 (from Q22 of Table 6)	The training programme generator could benefit of using the "feedback system".
Function 3 *(improving training course contents)* – this function helps to identify distinctive research results (potential results of DIH activities) that may be used to improve course contents.	
24 (from the definition)	It should help to identify distinctive research results (potentially results of DIH activities).
25 (from the definition)	It should be able to improve course contents based on inputs from DIH outcome experimentations.
26 (from Q3 of Table 6)	The training course contents should be available in different languages (e.g., English, French).
27 (from Q4 of Table 6)	The training course contents could be used in common collaboration spaces such as educational, industrial, services, and labs.
28 (from Q7 of Table 6)	The training course contents should be used by recognized users (who are not anonymous).
29 (from Q8 of Table 6)	The training course contents could benefit of computer-supported collaborative tools.
30 (from Q10 of Table 6)	The training course contents could be used for improving specific courses and majors (based on predefined topics).
31 (from Q11 of Table 6)	The training course contents could benefit of a secured database.
32 (from Q13 of Table 6)	The training course contents could be used in training and learning services for different schools, organizations, institutions, businesses, and companies.
33 (from Q14 of Table 6)	The training course contents could be used in training and learning services for different research centers, living labs, innovators, etc.
34 (from Q15 of Table 6)	The training course contents could benefit of supportive technologies e.g., web-based communication and collaboration.
35 (from Q21 of Table 6)	The training course contents should consider the trust and transparency principles and policies of the community.
36 (from Q22 of Table 6)	The training course contents could benefit from using the "feedback system".
37 (from Q25 of Table 6)	The improved training course contents that are delivered to learners need assessment.

Function 4 *(training execution support)* – this function provides the needed support for (a) training execution, training planning, and (b) learning engagement strategies.	
38 (from the definition)	It should support the training execution and training planning.
39 (from the definition)	It should support the learning engagement strategies.
40 (from Q1 of Table 6)	The training execution support should be used for different purposes (e.g., education, tutorials, developing competencies, promoting workforces, R&D).
41 (from Q3 of Table 6)	The training execution support should be available in different languages (e.g., English, French).
42 (from Q7 of Table 6)	The training execution support should be used by recognized users (who are not anonymous).
43 (from Q8 of Table 6)	The training execution support should benefit of computer-supported collaborative tools.
44 (from Q11 of Table 6)	The training course contents should benefit of a secured database.
45 (from Q13 of Table 6)	The training execution support could be used in training and learning services for different schools, organizations, institutions, businesses, and companies.
46 (from Q14 of Table 6)	The training execution support could be used in training and learning services for different research centers, living labs, innovators, etc.
47 (from Q15 of Table 6)	The training execution support should benefit from assistive technologies e.g., web-based communication and collaboration.
48 (from Q21 of Table 6)	The training execution support should consider the trust and transparency principles and policies of the community.
49 (from Q22 of Table 6)	The training execution support should benefit from a "feedback system".
50 (from Q25 of Table 6)	The training execution support should be used in the assessment of acquired knowledge by learners.
Function 5 (training quality assessment) – this function provides the needed support for designing the overall training performance-based assessment and reporting.	
51 (from the definition)	It should support the training quality assessment and report the results.
52 (from Q1 of Table 6)	The training quality assessment should be used for different purposes (e.g., education, tutorials, developing competencies, promoting workforces, R&D).
53 (from Q3 of Table 6)	The training quality assessment should be available in different languages (e.g., English, French).
54 (from Q7 of Table 6)	The training quality assessment should be used by recognized users (who are not anonymous).
55 (from Q8 of Table 6)	The training quality assessment should benefit of computer-supported collaborative tools.
56 (from Q11 of Table 6)	The training quality assessment should benefit from a secured database.
57 (from Q13 of Table 6)	The training quality assessment should be used in training services for schools, organizations, institutions, businesses, and companies.
58 (from Q14 of Table 6)	The training quality assessment should be used in training services for research centers, living labs, innovators, etc.
59 (from Q15 of Table 6)	The training quality assessment should benefit from supportive technologies e.g., web-based communication and collaboration.
60 (from Q16 of Table 6)	The training quality assessment should benefit from potential tools.
61 (from Q21 of Table 6)	The training quality assessment should consider the trust and transparency principles and policies of the community.
62 (from Q22 of Table 6)	The training quality assessment could benefit from a "feedback system".
63 (from Q23 of Table 6)	The training quality assessment could be used for measuring trainers' qualifications.
64 (from Q24 of Table 6)	The training quality assessment should consider the quality of training materials.
65(from Q25 of Table 6)	The training quality assessment should consider the quality of knowledge gained by learners.
66 (from Q26 of Table 6)	The training quality assessment should consider the quality of community operation.
67 (from Q27 of Table 6)	The training quality assessment should consider the quality of community outputs.
Function 6 (user identification and invitation) – this function is for identifying and inviting the specific/demanding participants such as trainers, experts, technical, and administrative.	
68 (from Q5 of Table 6)	It should support the identification and invitation of specific/demanding participants.

Function 7 (user's account management e.g., activation, deactivation) – this function is for managing accounts by providing different access rights or profiles and to facilitate activation/deactivation of accounts.	
69 (from the definition)	It should manage the user's account (e.g., activation, deactivation).
70 (from Q6 of Table 6)	It should suspend or even deactivate a user's account who does not follow the rules.
71 (from Q18 of Table 6)	It should manage the contributions of users to different domains, courses, majors, practices, issues, and events.
Function 8 (communication by means of "discussion forum") – this function provides a message and discussion boards for asynchronous communication among users.	
72 (from Q9 of Table 6)	It should facilitate collaboration among users by providing a "discussion forum".
Function 9 (managing internal interactions and transactions) – this function helps manage various interactions and transactions between users e.g., sharing the resources and training/learning materials.	
73 (from Q12 of Table 6)	It should support internal interactions and transactions such as sharing the resources, training, and learning materials.
74 (from Q17 of Table 6)	It should manage the participation of users.

Further evaluation of the considered LF functions by the technical team led to adjusting the number of functions from 9 to 7 functions. Therefore, the new proposed general functions (named functions 6 and 7) are:

- *Function 6 (user management)* – this function is for identifying, inviting, and maintaining the specific/demanding participants such as trainers, experts, technical, and administrative for particular purposes (e.g., providing support in training, execution, or consult, participating in programmes, activities, and/or events).
- *Function 7 (information/knowledge management)* – this function is for managing users' personal information, contributions, and transactions.

Following the above-mentioned adjustment, the number of questions in the questionnaire is reduced as well. Given that, the number of important and needed features and capabilities that need to be contained in the LF is also altered. Additionally, one more (general) function is considered in the questionnaire named "Global or Transversal Features", representing the features that all the functions should integrate as well as any platform user will face when accessing the system. For the LF functions feasibility questionnaire, 34 related questions were formulated in total.

The feasibility of the functions of LF is asked and assessed by the project partners and stakeholders through a checklist in the questionnaire. There are six possible answers in the checklist for each question, namely, strongly disagree (SDA), disagree (DA), agree (A), strongly agree (SA), I don't know, and I'm not sure (now). The evaluators (partners, constituting a kind of "focus group") not only can choose one of these possible answers, but they can also insert comments and feedback (if needed) about each addressed item in each question.

The main results of this step of evaluation (average of the popularity of functions/ weighted average) were achieved from analyzing the 6 received questionnaires which are summarized in Table 12. In the method for analyzing the obtained data from respondents and calculating the statistical answers given to the questions (addressed in the questionnaire), a decision was made to give weight to each answer in the checklist. The attributed weights are as follows: (SDA = 1), (DA = 2), (A = 3), (SA = 4), (I don't know = 0), and (I'm not sure = 0). In the calculation, each answer (for a single question) was first multiplied with the attributed weight and then they were summed up and lastly divided by the total number of respondents. The received responses were analyzed manually. Table 11 presents the developed questionnaire for evaluating the feasibility of LF functions.

Table 11: Developed questionnaire for evaluating the feasibility of LF functions.

Questionnaire						
Global or Transversal Features	SDA	DA	A	SA	IDK	IANS
1) The platform should be a kind of portal to be used for different purposes (e.g., education, tutorials, developing competencies, promoting workforces, R&D).						
2) The platform should be available in different languages (e.g., English, French).						
3) Any of ECP's main functions (listed in the next questionary groups) should be available only for recognized/registered users (who are not anonymous).						
4) It is important that the ECP could benefit from supportive technologies for specific collaborations such as GITs, LinkedIn, Twitter, etc.						
5) It is important that the ECP has the possibility of generating any economic benefit from providing supportive training and learning services for different organizations such as schools, companies, research centers, and living labs.						
6) The ECP should follow a set of pre-determined trust and transparency principles and policies for the community.						
7) It is important that the ECP has a mechanism of feedback to improve future versions of the system.						
Function 1 *(dynamic training design)*						
8) It should create and develop new training and educational courses and lessons for the existing students/employees.						
9) It should take into consideration the learning assessments that invoke changes in the programme (which help students better fulfill the learning objectives).						
10) The training design function may benefit from computer-supported collaborative tools. While people are designing may intend to discuss any particular situation with others.						
11) The training design should be used for creating specific courses and modules based on predefined topics and experiences (this may. uses a particular specification system able to record such experiences e.g., xapi.com.						
Function 2 *(training programme generator)*						
12) The training programme generator should generate the training programme accordingly to determine the profile characteristics of the student.						
13) The training programme generator should be dynamic to actively readjust the programme depending on the student's performance. This means that after the creation of a programme it may readjust the contents of the lesson to improve the learning of a specific student.						
Function 3 *(improving training course contents)*						
14) This function should help to collect ideas for testing/research in DIH labs.						
15) It should identify/evaluate distinctive research results from DIH research activities able to be integrated in course contents.						
16) It is important that this function could use as input for the assessment results of measuring the knowledge gained by learners. Such data may help to identify the weaknesses and strengths of the course contents.						
Function 4 *(training execution support)*						
17) This function should support the training execution and training planning.						
18) It should support the learning engagement strategies.						
19) It is important that this function could provide an assessment feature able to measure the knowledge gained by learners.						
Function 5 (training quality assessment)						
20) This function should support the training quality assessment and report the results.						
21) The training quality assessment should benefit from potential tools.						
22) The training quality assessment could be used for measuring trainers' qualifications.						
23) The training quality assessment should consider the quality of training materials.						

24) The training quality assessment should consider the quality of community operation and outputs.						
Function 6 (user management)						
25) This function should manage the user's accounts (profiling and identification).						
26) It should support specific users' activation and deactivation.						
27) It should help to identify users who do not follow the rules.						
28) It should facilitate managing different role users allowing multi features as enabling to contribute to different tasks/domains, courses, issues, and events.						
29) This function should support the identification and invitation of specific/demanding participants.						
Function 7 (Information management)						
30) This function helps manage various interactions and transactions such as sharing resources, training, and learning materials.						
31) This function helps manage the participation profile in particular activities/events.						
32) This function manages the dissemination of information (interest topic per type of users).						
33) This function should facilitate the asynchronous discussion/collaboration between different users through a discussion forum.						
34) It should be able to manage different discussions (from forums) or events categorization.						

The results of evaluating the feasibility of LF functions are presented in Table 12.

Table 12: Results of evaluating the feasibility of LF functions.

Considered LF functions	Number of questions per function	Weighted average	Percentage of the popularity of functions
Global or Transversal Features	7	3.60	90%
Function 1 - Dynamic training design	4	3.15	78.75%
Function 2 - Training programme generator	2	3.10	77.50%
Function 3 - Improving training course contents	3	3.57	89.25%
Function 4 - Training execution support	3	3.63	90.75%
Function 5 - Training quality assessment	5	3.26	81.50%
Function 6 - Users management	5	3.57	89.25%
Function 7 - Info Management	5	3.35	83.75%

To gain a better view of the results of this step of evaluation, they are also displayed in a graph in Figure 4.

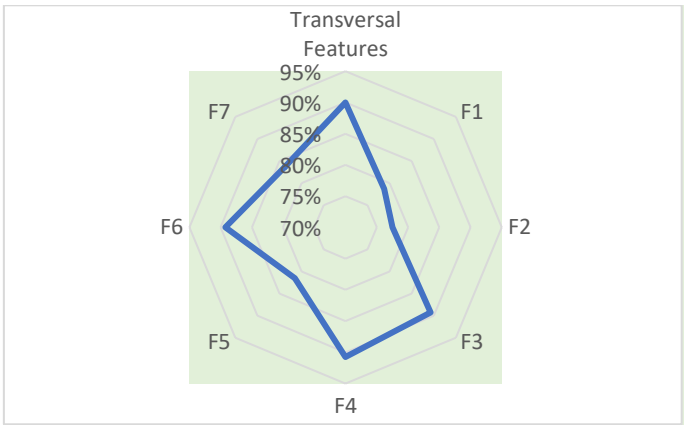


Figure 4: Percentage of the popularity of LF functions in feasibility evaluation.

The results of this step of the evaluation show that the highest percentage of attention is given (by partner evaluators) to Function 4 (training execution support) with 90.75%, whereas the lowest percentage of popularity is given to Function 2 (training programme generator) with 77.50%.

3.1.8 Evaluating the effectiveness of selected components, features, factors, and LF functions (Step 6)

After evaluating the adequacy (step 4) and feasibility (step 5) of selected items and LF functions, the stakeholders and partners proceed to effectiveness evaluation (step6). In a group agreement, this step of the evaluation was performed through a kind of Delphi method (in some plenary meetings). Meaning that in this step no questionnaire was used. Therefore, during the plenary meetings that the stakeholders and partners had from 7th to 11th February 2022, the effectiveness of the selected components, features, factors, and LF functions was evaluated collaboratively. For this purpose, the selected items and functions from the feasibility step were evaluated at this stage - from the effectiveness point of view – through some rounds of group discussions. After deep evaluation, the stakeholders and partners lastly came to the conclusion that the selected items and LF functions are effective enough to be considered and used in LF. In addition to them, during these rounds of meetings the technical partners presented the first scheme of the proposed LF. The LF is illustrated in Figure 12 and presented with detailed information in section 6. Different aspects of the LF were also evaluated by the stakeholders and partners. As a consequence, the evaluators agreed that the proposed LF is in line with the considered goals and expectations. Given that, the technical partner took over the process of LF development and implementation. The technical partners have also tried to measure the appropriateness of the proposed evaluation process used in this work. This measurement can give an indication of how much the proposed evaluation process is appealing to the stakeholders and partners, and to what extent it could be useful for the case of this work. The results of this measurement are presented in the following subsection.

4. Evaluating the appropriateness (validity) of the proposed evaluation process

The proposed evaluation/governance process shown in Figure 2 is used to evaluate (through multiple stages) the adequacy, feasibility, effectiveness, and efficiency of the components, factors, features, and functions adapted for LF. In order to check that the proposed evaluation/governance process is appropriate (valid) to be used for this purpose, the technical team tried to collect the opinion of other partners and stakeholders in this regard. Hence, a questionnaire is developed, containing 6 considered validation criteria and parameters (completeness, purposefulness, perceived usefulness, perceived ease of use, cost-effectiveness, and reasonability) and 11 respective questions (see Table 13).

Table 13: Questionnaire for evaluating the appropriateness (validity) of the proposed evaluation process.

Criteria / Parameters	Questions	SDA	DA	A	SA	IDK	IANS
Completeness	1. The evaluation process encompasses the necessary parts for the proper evaluation of the identified components, features, and factors that might be used in (the creation, development, and implementation) of LF.						
	2. The evaluation process comprises the necessary steps for the proper evaluation of the considered functions of LF.						
Purposefulness	3. The evaluation process can provide satisfactory results.						
	4. The evaluation process can create the expected value.						
Perceived usefulness	5. The evaluation process is useful for evaluating the identified components, features, and factors that might be used in (the creation, development, and implementation) of LF.						

	6. The evaluation process is useful for evaluating the considered functions of LF.						
Perceived ease of use	7. The evaluation process is clear and easy to understand.						
	8. The evaluation process is clear and easy to follow.						
Cost-effective	9. The evaluation process helps us to save resources (e.g., time, effort, and costs) in identifying the required features and capabilities for LF.						
Reasonability	10. The evaluation process can meet the expectations in identifying the required features that might be used in the creation, development, and implementation of LF.						
	11. The evaluation process has a reasonable chance of success in the evaluation of the considered functions of LF.						

The validation criteria and parameters are set by the technical team with respect to the proposed criteria and parameters in the literature, the strategic objectives of the project, and the expectations from LF. The formulated questions in this questionnaire should be rated on a 6-point Likert scale (Likert, 1932) including strongly disagree (SDA), disagree (DA), agree (A), strongly agree (SA), I don't know (IDK), and I am not sure (IANS) as we did and considered in step 5 (feasibility of LF functions). The Likert scale questions are formulated to understand the level of agreement of respondents (partners and stakeholders) with the appropriateness of the proposed evaluation process. The questionnaire was sent to 9 groups of partners and stakeholders. The results of analyzing their answers/opinions are presented in Table 14.

Table 14: Results of evaluating the appropriateness (validity) of the proposed evaluation process.

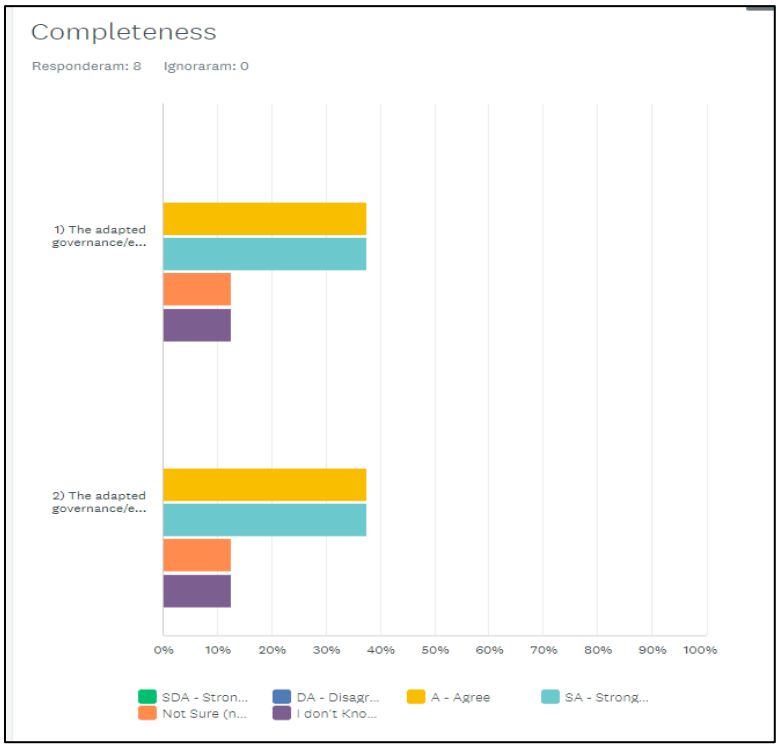
Criteria / Parameters	Feedback Number	Questions	Weighted average	Percentages	SDA	DA	A	SA	IANS	IDK
Completeness	9	Q1	2.63	65.75%	0	0	3	3	2	1
	9	Q2	3	75%	0	0	4	3	1	1
Purposefulness	9	Q3	3.22	80.05%	0	1	5	3	0	0
	9	Q4	2.78	69.05%	0	1	5	2	1	0
Perceived usefulness	9	Q5	3.44	86%	0	0	5	4	0	0
	9	Q6	3.22	80.05%	0	1	5	3	0	0
Perceived ease of use	9	Q7	2.44	61%	0	1	4	2	2	0
	9	Q8	2.22	55.50%	0	2	4	1	2	0
Cost-effective	9	Q9	2.57	64.25%	0	2	2	2	1	2
Reasonability	9	Q10	3.13	78.25%	0	0	3	4	1	1
	9	Q11	3.11	77.75%	0	0	4	4	1	0
Average	-	-	2.88	72%	0	8	54	31	11	5
Max	-	-	4.00	100	55	55	55	55	55	55

The questionnaire is made by SurveyMonkey (which is a well-known online application/tool used for creating and running professional online surveys). As an illustration, the results of analyzing the criteria of "completeness" performed by SurveyMonkey are displayed in Figure 5.

Taking Table 14 into account, it can be stated that:

- All the considered criteria and parameters for evaluating the appropriateness (validity) of the proposed evaluation process got the (acceptance) percentage over 50, a reasonable indicator of general acceptance.

- Among the 11 questions addressed in this survey, 5 questions had the (acceptance) percentage lower than the average percentage (72). The other questions had (acceptance) percentage of over 72.
- The given answers show that there is not any strong disagreement for the addressed points (questions). However, there are only 8 disagreements in total which is not high.
- Totally, there are 54 agreements and 31 strongly agreements which is a considerable positive reaction.
- As a whole, there are only 11 answers which claim that "I am not sure", and 5 answers that said, "I don't know". Indeed, this rate is not high at all. Since the proposed evaluation process is assessed theoretically and conceptually at this stage, thus a percentage of ambiguity and uncertainty is understandable. On the other side, the related feedbacks show that the evaluators/partners understood clearly and objectively the questions.



	SDA - STRONGLY DISAGREE	DA - DISAGREE	A - AGREE	SA - STRONGLY AGREE	NOT SURE (NOT UNDERSTOOD THE QUESTION)	I DON'T KNOW (UNDERSTOOD THE QUESTION)	TOTAL	MÉDIA PONDERADA
1) The adapted governance/evaluation process encompasses the necessary parts for the proper evaluation of the identified components, features, and factors that might be used in (creation, development, and implementation) of the learning framework/platform.	0.00% 0	0.00% 0	37.50% 3	37.50% 3	12.50% 1	12.50% 1	8	3.00
2) The adapted governance/evaluation process comprises the necessary steps for the proper evaluation of the considered functions for the framework/platform.	0.00% 0	0.00% 0	37.50% 3	37.50% 3	12.50% 1	12.50% 1	8	3.00

Figure 5: A screenshot of the analysis made with SurveyMonkey.

Taking Table 13 into account, it can be stated that:

- All the considered criteria and parameters for evaluating the appropriateness (validity) of the proposed evaluation process got the (acceptance) percentage over 50, a reasonable indicator of general acceptance.
- Among the 11 questions addressed in this survey, 5 questions had the (acceptance) percentage lower than the average percentage (72). The other questions had (acceptance) percentage of over 72.
- The given answers show that there is not any strong disagreement for the addressed points (questions). However, there are only 8 disagreements in total which is not high.
- Totally, there are 54 agreements and 31 strongly agreements which is a considerable positive reaction.
- As a whole, there are only 11 answers which claim that "I am not sure", and 5 answers that said, "I don't know". Indeed, this rate is not high at all. Due to the fact that the proposed evaluation process is assessed theoretically and conceptually at this stage, thus a percentage of ambiguity and uncertainty is understandable. On the other side, the related feedbacks show that the evaluators/partners understood clearly and objectively the questions.

5. Function development and clarification

Following the progress of the work and considering the (general and specific) requirements of LF, some developments are made to the definition of the functions according to the discussions made in group meetings. Thus, improved explanations for each function are presented in the following toward a clarification of specific characteristics of the functions based on the last considerations.

Function 1 *(dynamic training design)* – this function supports the process of designing training courses. In this function, dynamicity refers to the flexibility of changing the (designed) training courses/syllabus or shifting from one to another course/syllabus based on learners' (student or worker) interests, background knowledge, skills, and competencies. Furthermore, as is shown in Figure 6, there is a considered template for assessing the knowledge, skills, and competencies that the learners gained in each (designed) training course/syllabus. If the results of the assessment show that the learner acquired the needed knowledge, skills, and competencies (considered in the object of the course/syllabus), he/she could then move up to a higher level of the course. But, in case, the learner fails to pass the course/syllabus, he/she needs to learn (through another designed course/syllabus) the basic information related to the course/syllabus. This approach provides dynamicity and flexibility to course selection and change. Appendix A provides a better view of Figure 6.

Enhance	Learning Activity Syllabus									
ENHANCE Domain	Maintenance									
Course Title	Advanced Maintenance strategies									
Activity Title	Sensor Network design									
Activity Acronym	SND									
Activity Description related to I4.0	Descriptions									
Keywords	Sensors	Design								
Teaching Task related to I4.0	Topics		Teaching Plan					Learning Path		
	Hard Skill		Delivery Method (gamification, case study, simulation...)		Teaching Material	Duration (Hrs)	Soft Skill	Assesment	If FAIL goes to	If PASS goes to
1							.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 3 (MDIS)	task 2 (SND)
2										
3										
4										
5										
6										
Meta Skills	To be a									
Module Outcomes	Participants will be able to		Participants will be able to							
Target Group (students, workers...)	Master students	SME personnels								
Assessment Method	Project report, Project presentation, Assessment rubric for teamwork									
Teaching Material										
Equipment	LoRA kits	Matlab toolbox	Cloud server							
Multimedia	Lecture notes	Role play scene setup								
Content URL	Video URL									
Class requirements (equipement that participants should bring)	Computer									
Prerequisites (previous modules that student should attend)	Data acquisition and analysis									
Total duration (Hrs)	7									

Figure 6: Considered template for assessing the knowledge, skills, and competencies gained by the learner in each course.

Figure 7 gives an example of course dynamicity. On the left side of the Figure, there is a list of the designed courses/syllabus. The first course/syllabus (advanced maintenance strategies) contains 6 Activities/Tasks. If the assessment shows that some learners fail over and over to pass, for example, the Activity/Task 1.3, the respective professor/author would design/generate a new or sub Activity/Task to help the learners to improve and gain the required knowledge, skills, and competences by taking the new or sub Activity/Task.

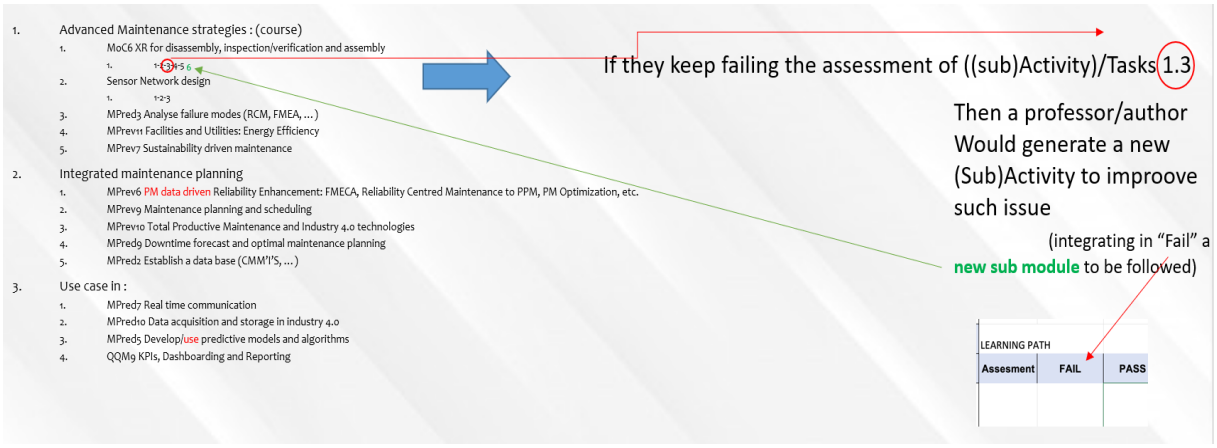


Figure 7: Example of course dynamicity when the learners fail in the assessment.

Function 2 *(training programme generator)* – this function helps to generate the required training programme accordingly to (a) determined the profile characteristics of the learners and (b) defined the objectives of training. The generated programme will be classified under related courses and would be accessible for use by learners. Each learner, based on his/her background and interest, could pick as many courses and programme as he/her could possibly take over. For example, as it is depicted in Figure 8, one learner who is a student decides to pick two Activities/Tasks (1.3 and 3.2) from the course

of advanced maintenance strategies, but another one who is an engineer takes the other two Activities/Tasks (1.2 and 3.1).

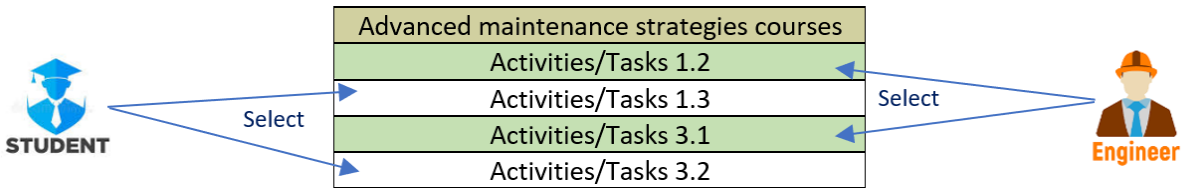


Figure 8: Selecting the desired Activities/Tasks by learners.

Function 3 (*improving training course contents*) – this function helps to improve the content of the training course, qualitatively and quantitatively. The content creators might come to the conclusion that the created contents for the training courses need some improvement. As illustrated in Figure 9, the content improvement which stands on the knowledge model can be done by taking two processes:

a) Knowledge creation process — in this process, the related problems will be first identified (mainly in the DIHs). Then, based on the research and experiments that will be respectively conducted, the understanding of the scope of the content will be increased. Afterward, the potential solutions could be suggested, and the solutions will be lastly assessed to ensure that they can improve the content adequately.
b) Training implementation process — in this process the training courses will be initially designed. They will be then developed according to the objectives of the training programme. Then after, the training content will be executed/used by the trainers and trainees. Lastly, through the training assessment, the strengths and weaknesses of the contents will be identified and then improved consequently. Such assessment methods could for example provide valuable information about the quality, quantity, and effectiveness of created content as well as determine where changes are needed. As such, the assessment can pave the way for gradually and continually improving the contents of the training courses.

The improved contents can help to create and increase the sustainability of the training course.

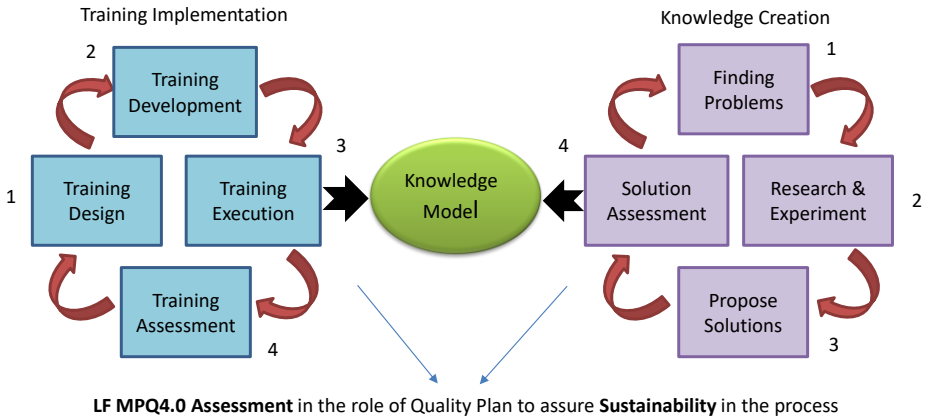


Figure 9: Improving the contents of training courses through assessments in the process of training implementation and knowledge creation.

Function 4 (*training execution support*) – this function provides some support for training planning, training management, and training execution. Meaning that this function will be integrated into the Learning Management System (typically Moodle) to provide customizable and trusted online learning solutions. For example, creating an e-learning platform and tailoring the learning environment that helps the learners considerably in conceptualizing the various courses, course structures, and curriculum thus facilitating interaction with others. There is a possibility to enhance the functionality of training execution by following the standard of Experience API (or xAPI). The xAPI, which is shown in Figure 10, not only helps to track learners' performance but also assists to store and retrieve the records of learners' performance and share these data across the LF.

Figure 10: Experience API (or xAPI)

Function 5 (*training quality assessment*) – this function, in line with function 1, supports the process of training quality assessment. The function might assess the quality and appropriateness of one or some of the following factors:

a) Programme objectives (clarity and achievement),
b) Facilities and staff,
c) Course materials and mix of classroom and hands-on training, and
d) Programme strengths and weaknesses and needed improvements.

In case, the assessment identifies a problem in the above-mentioned factors, the needed action should be then taken accordingly. For example, as it is shown above in Figure 7, when the results of the assessment show that some learners continuously fail to pass a specific Activity/Task in a course, it could be an indicator of the kind of problem in that specific Activity/Task. Therefore, the respective professors or authors should either improve and modify the Activity/Task or design a sub Activity/Task. In this way, the professors or authors should remove the problem and provide a better training Activity/Task for learners.
In this regard, different methods of assessment can be taken into account. For example, the assessment can be performed by the student through a designed questionnaire for this purpose. As such, the xAPI can provide a standard means for collecting data from training and assessment experiences. The specification allows different systems to communicate and share data, which can then be stored and analyzed. This helps ENHANCE to make better decisions by collecting, tracking, and quantifying learning activities to see what works and what doesn't.

Function 6 (*user management*) – this function can manage the features that are related to the users (learners) such as profiles, roles, permissions, and communication. This function allows managing

users' account and their access to various resources like systems, devices, applications, learning contents, storage systems, networks, and more. Moreover, user management can be used for identifying and inviting the specific/demanding participants such as trainers, experts, technical, and administrative for a particular purpose such as (a) providing support in training, execution, or consult, and (b) participating in programmes, activities, and events (see Figure 11).

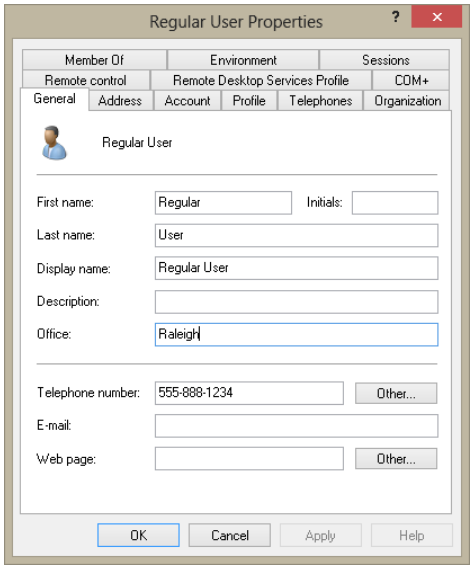


Figure 11: User management function.

Function 7 (*information/knowledge management*) – this function represents a cycle of processes that support the learning activities namely, identifying information needs, acquiring information, organizing and storing information, developing information, distributing information, and using the information in LF. This function helps to maintain information in a place where it is easy to access. The core goal of this function is to increase the overall knowledge level of the learners/students and the community as a whole.

At the end of this section, it should be noted that after completing the three steps of evaluation (steps 4 - 6), conducting some presentations and several rounds of group discussions, making group agreement, and before moving to the phase of implementation (step 7), the LF for ENHANCE was proposed which is presented in the following section.

6. Proposed learning framework

LF is a research-informed model for course design that helps instructors align learning goals with classroom activities, create motivating and inclusive environments, and integrate assessment into learning. Furthermore, the LF provides a guide for professional practice, curriculum decision-making, teaching, and learning to ensure consistent high-quality practices are in the learning environment.

Taking all the above-mentioned issues into consideration, the first scheme of LF shown in Figure 12 is proposed by technical partners. The right side of Figure 12 shows the proposed LF, and the left side addresses the related functions. The proposed LF contains a number of specific components that work together to facilitate the process of training and learning. Indeed, it is considered the first scheme of LF, because the LF could embrace all components shown on the side of the Figure or could be part of that, and there is still no high certainty of whether it could be easily performed in reality or not. In another word, at this stage, the LF is appraised and presented theoretically, but in practice, some changes might occur in the LF (in terms of type and number of components). It is noteworthy that the

application of all these components and practically accommodating them into the LF is an extremely complex task.

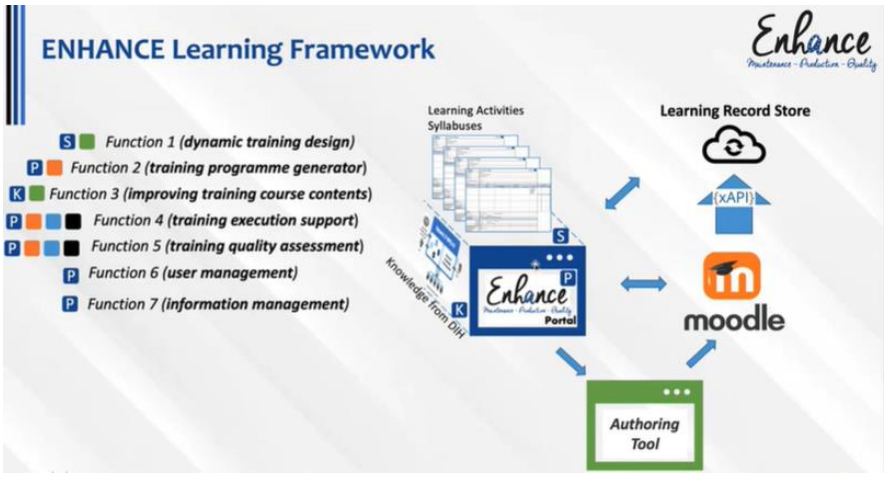


Figure 12: ENHANCE Learning Framework.

To make a clarification about the presented components in LF, a brief description is provided for each one in Table 15.

Table 15: Descriptions of the components proposed for the Learning Framework.

Descriptions
Learning Record Storage (LRS) – is a data storage system that serves as a repository for learning records collected from connected systems where learning activities are conducted. Every other tool which sends or retrieves learning activity data will interact with the LRS as the central store.
xAPI – is an e-learning software specification that allows learning content and learning systems to speak to each other in a manner that records and tracks all types of learning experiences. Learning experiences are recorded in LRS.
Moodle – is an open-source learning management system that allows to build and upload e-learning content, deliver it to learners, assess them on that content, track their progress and recognize their achievements. Moodle provides a central space on the portal where learners can access a set of tools, resources, and courses anytime anywhere.
Authoring Tools – is software that exists either standalone or alongside the LF. It enables users to create eLearning courses and content using various forms of media. The main job of an authoring tool is to make developing content more efficient and open up possibilities that would be infeasible or too time consuming to develop without a dedicated tool.
Syllabuses – is a document that communicates information about a specific academic course or class and defines expectations and responsibilities. It is generally an overview or summary of the curriculum. A syllabus is a guide to a course and what will be expected of learner in the course. Generally, a syllabus includes course policies, rules and regulations, required texts, and a schedule of assignments.
ENHANCE Portal – is a specially designed web-based platform that collects information from different sources (e.g., emails, online forums, and search engines) into a single user interface and presents users with the most relevant information for their context. The portal can offer a range of information resources and often gives users some basic services. For example, provides users with access to search engines, community chat forums, personalized home pages, and email access.
Knowledge from DIHs – refers to the facts, truth, awareness, and findings that are identified, acquired, created, or developed by DIHs.

The relationships of the LF functions (shown on the right side of Figure 12) with the functions of LF are presented in Table 16.

Table 16: Relationship of the functions and components of the learning Framework.

Relationship of the functions and components of learning Framework	
Functions	**Relationships with components**
Function 1 (dynamic training design)	- Syllabuses - Authoring tool
Function 2 (training programme generator)	- ENHANCE Portal - Moodle
Function 3 (improving training course contents)	- Knowledge/information from DIHs - Authoring Tool
Function 4 (training execution support)	- ENHANCE Portal - Moodle - xAPI - LRS
Function 5 (training quality assessment)	- ENHANCE Portal - Moodle - xAPI - LRS
Function 6 (user management)	- ENHANCE Portal
Function 7 (information/knowledge management)	- ENHANCE Portal

In Figure 12 different parts of LF are visualized such as its components and their interactions. As is shown in Figure 12, generally the learning activities and syllabuses are created and made available in ENHANCE Portal. The learning activities and syllabuses could be improved and updated by the findings of DIHs (of Morocco and Tunisia). The process of creating and developing the learning activities and syllabuses will be supported directly or indirectly by other components of LF. For example, the Authoring Tool allows instructional designers to create and customize responsive online courses and content. The Authoring Tool can also help in creating software simulations, gamification, and building questions. Moodle enables the (course and content) designers to create online courses, add assignments, and keep an eye on learners' progress. Moodle also allows for communication with the learners and encourages communication between them in forums and discussions. Besides, Moodle allows for extending and tailoring the learning environment using community-sourced plugins. The xAPI introduces the standards that allow the tracking, storing, and sharing of the learning experience of the learners across, LF, platforms, and in multiple contexts. With xAPI, the authorities can track anything the learner does, whether that is more innovative learning experiences (such as games, videos, or mobile apps) or job tasks that put learning into practice. The LRS is the heart of any xAPI ecosystem, receiving, storing, and returning xAPI statements. The LRS is essential to do anything with xAPI. Every other tool which sends or retrieves learning activity data will interact with the LRS as the central store. The LRS provides a server (i.e., a system capable of receiving and processing web requests) that is responsible for receiving, storing, and providing access to learning records.

7. Conclusions

This document is produced as a part of ENHANCE project to provide a global overview of the LF. The LF in this work is considered a research-informed model for course design that helps instructors align learning goals with classroom activities, create motivating and inclusive environments, and integrate assessment into learning. To identify, select, and adapt the main features, factors, components, and needed functions of LF, a deep literature review is conducted around related topics such as MCL. By evaluating the 15 successful and active examples of MCL, not only a better understanding of the exciting research and knowledge gained but also a number of potential features, factors, and components are identified for integration into the LF. The evaluation/governance process is proposed

to systematically evaluate the adequacy, feasibility, effectiveness, and efficiency of identified, selected, and adapted features, factors, and components. The results of analyzing the first 6 steps of the evaluation/governance process are presented in this document. The findings gained from the evaluations, group discussions, and consultations assist the technical team in UNL to propose the first scheme of LF. The LF will manage the training implementation through a detailed specification of the 42 activities. These specifications follow a specific template that encloses details such as skills and other programmatic information.

In the next stage, the LF will be implemented in the real world. Then, the LF will be tested by a small group of users (e.g., 100 students), aiming at finding the possible constraints and problems. When the LF is well developed, it could be then utilized by a wide variety of users.

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Appendix A

Considered template for assessing the knowledge, skills, and competencies gained by the learner in each course.

Enhance	Learning Activity Syllabus									
ENHANCE Domain	Maintenance									
Course Title	Advanced Maintenance strategies									
Activity Title	Sensor Network design									
Activity Acronym	SND									
Activity Description related to I4.0	Descriptions									
Keywords	Sensors	Design								
Teaching Task related to I4.0	**Topics**		**Teaching Plan**					**Learning Path**		
	Hard Skill		**Delivery Method (gamification, case study, simulation...)**		**Teaching Material**	**Duration (Hrs)**	**Soft Skill**	**Assesment**	**If FAIL goes to**	**If PASS goes to**
1							.Problem Solving .Critical thinking .Team working . Presentation . Infographic communication	Question 1	Task 3 (MDIS)	task 2 (SND)
2										
3										
4										
5										
6										
Meta Skills	To be a									
Module Outcomes	Participants will be able to		Participants will be able to							
Target Group *(students, workers...)*	Master students	SME personnels								
Assessment Method	Project report, Project presentation, Assessment rubric for teamwork									
Teaching Material										
Equipment	LoRA kits	Matlab toolbox	Cloud server							
Multimedia	Lecture notes	Role play scene setup								
Content URL	Video URL									
Class requirements *(equipement that participants should bring)*	Computer									
Prerequisites *(previous modules that student should attend)*	Data acquisition and analysis									
Total duration *(Hrs)*	7									