WP3

D3.2: Innovative teaching methodologies

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SEB CoVE
SMART ELECTRICITY FOR BUILDINGS

D3.2. INNOVATIVE TEACHING METHODOLOGIES

SMART ELECTRICITY FOR BUILDINGS

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Abstract

This report explores innovative teaching methodologies tailored for the intended Vocational Education and Training (VET) within the SEBCoVE project. It presents a comprehensive desk research analysis, identifying best methodological approaches that will enhance learning experiences and effectiveness of the training for the Smart Electricity for Buildings (SEB) sector. The study emphasizes modern learning and teaching paradigms and approaches for VET and a technology-enhanced learning, in line with European VET policy. Key findings highlight the importance of aligning this training with industry needs, engaged learners, a comprehensive learning for quality occupational performances and proven methodologies that leverage advanced educational technologies. Also, collaboration between VET institutions and industry for innovative learning and teaching frameworks must be fostered. The report concludes with a general recommendation for adopting a common learner-centred, technology-enhanced, and hybrid teaching model conducive to innovative teaching concretions for the SEB education and training that can operate as good practices for VET institutions and systems interested in the SEB sector.

Executive summary

Introduction

This report, developed within the framework of the **Smart Electricy for Buildings – Centres of Vocational Excellence -SEBCoVE- project** / WP3 / Task 3.3, presents an in-depth desk research analysis on innovative teaching methodologies applicable to the training model and delivery of the qualifying programs to be developed, piloted and validated in the project's timeframe. The study aims to support the design of this training that foster excellence in education and workforce development for the SEB sector.

Objectives

The primary objectives of this research are:

1. Research teaching methodologies for technical and vocational education and training, especially applicable to the SEBCoVE project's VET model and training offer (curricula, programs, qualification pathways).

2. Research educational technologies that can support these methodological approaches.
3. Research general VET innovation factors and approaches that can be applied to the SEBCoVE project's goals.
4. Collect and research inspiring experiences of VET innovation among the regions and countries of the consortium, specially close to the training and education for the SEB sector.
5. Identify criteria for adoption of methodologies and educational technology that result in quality and potentially innovative teaching for the SEBCoVE project.
6. Recommend a common pedagogical stance for the SEBCoVE's VET that can result in a good teaching practice, for a generalized adoption beyond the project's end.

Methods

A comprehensive gathering and review of existing literature about learning and teaching principles, teaching approaches and technology applicable to technical and vocational training, European VET policies, and notorious innovations in the broad VET space. The study considered learner-centred education, competency-based training, experiential learning approaches, and the integration of traditional, digital and other emerging educational technologies. The research also examined national and regional case studies of methodological transformation that give context and concretion to main findings and the recommendation for the SEBCoVE project.

Key findings

A set of conditions will shape the innovative teaching within the SEBCoVE project, if this innovation lies on a methodological or pedagogical transformation. These are:

1. **Ensuring alignment with industry**. The programs and the promoted teaching in the SEBCoVE's VET programs will be oriented towards sector-specific competency requirements and occupational roles.
2. **Improving the training service**. The teaching approach will be suited to the education or training service conceived, including purposes, certificates, pathways, courses and delivery modes.

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3. **Proven methodologies**. The pedagogical approach and the associated educational technology will be consistent with modern learning and teaching paradigms, particularly those applied in adult learning, VET and HE, and will consider the pedagogical recommendations for VET from European authorities, too. Better, if newer methods and technology are backed by some evidence or science.
4. **Capability building**. Trained teachers and instructors, resources, documented teaching processes and a quality management model will be required to pilot the innovation and for later adoption.
5. **Empirically tested**. The teaching conceived (as a service), with its innovative features, will be developed, piloted and validated in real training/education settings provided by the constituted regional CoVEs constituted and developed within the project.
6. **Scalable and transferable**. Finally, the training with its methodological and technological components will be documented and configured as a comprehensive process with details about flexibilities and conditions for its institutionalization (after the project).

Recommendations

Based on these findings, the SEBCoVE's training should adopt **a learner-centred, technology-enhanced, and hybrid teaching model** that integrates the following:

- Methodologies, methods and technology for diverse learning outcomes.
- Project-based and inquiry-driven methodologies, especially for integrated learning outcomes representing the occupational referents from the SEB sector.
- Digital learning tools and advanced simulation technologies, such as XR-based technical training or serious games.
- A structured framework for a generic blended learning model.
- Strong engagement with industry stakeholders for collaborative work-based learning initiatives.

Conclusion

The adoption of these methodologies and technologies within the SEBCoVE training model will foster innovation, improve learning outcomes, and ensure alignment with industry needs. The next steps include piloting and validating these approaches and resources in real-world VET settings, followed by their broader dissemination and institutionalization within the SEB sector.

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Glossary

AI – Artificial Intelligence

AR – Augmented Reality

CBL – Case-Based Learning

CL – Collaborative Learning

CVET – Continuing Vocational Education and Training

EdTech – Educational Technology, and shorted name for the industry related.

EQF – European Qualifications Framework

FC – Flipped Classroom methodology.

IVET – Initial Vocational Education and Training

LMS – Learning Management System

MOOC – Massive Open Online Course

MR – Mixed Reality

PBL – Problem-Based Learning

PjBL – Project-Based Learning

SBL – Scenario-Based Learning

SimBL – Simulation-Based Learning

SG – Serious Games and gamification

TBL – Task-Based Learning

VET – Vocational Education and Training

VR – Virtual Reality

WBL – Work-Based Learning

WTBL – Whole Task-Based Learning

XR – Extended Reality (including AR, VR, and MR)

1. Introduction

This report titled ***D3.1. Innovative Teaching Methodologies*** is the deliverable associated to the Task 3.3. *Defining Innovative Teaching Methodologies*. In turn, this task makes part of the WP3. *SEBCoVE Design* of the Smart Electricity for Buildings – Centres of Vocational Excellence – SEBCoVE project.

This report summarizes the findings of desk research of good practices, especially in existing digital teaching methods, that can be adopted by VET providers and systems targeted to “electricians” and other professionals for the SEB sector.

It is justified because a distinctive teaching or methodological approach is required to define the training model and training provision of the SEBCoVE project. In addition, this teaching methodology should have innovative traits that contribute to teaching and learning excellence, as it is expected from VET providers within the European CoVEs initiative.

Understandably, in the SEBCoVE project this activity and resulting report makes part of a design work (WP3), it is based on strategic research (WP2) and some initial developments (WP4), and in turn will inform developments and training pilots (WP4 and WP5). This report is mainly intended for internal uses, but it is also useful for dissemination purposes of the project and other uses.

This has been also a collaborative work with contributions from all partners, and especially from constituted CoVEs.

1.1. Purpose/Objectives

1. Research current teaching paradigms and methodologies for technical and vocational education and training, especially applicable to the VET model and curricula of the SEBCoVE project.
2. Research educational technologies, including emerging ones, that can support these methodological approaches.
3. Research contexts, factors and approaches for VET innovation and its institutionalization that can be applied to the SEBCoVE project’s objectives.
4. Collect and research experiences of VET innovation among the regions and countries of the consortium that can be inspiring for the intended innovation in

the SEBCoVE project.

5. Identify criteria for adoption of methodologies and educational technology that result in quality and potentially innovative teaching for the SEBCoVE project.
6. Recommend a common pedagogical stance for the SEBCoVE's VET that can be flexibly instantiated, piloted and validated regionally as a good practice, for a generalized adoption beyond the SEBCoVE project's timeframe.

1.2. Document organization

The document is basically organized as follows:

- After this introduction, the context of the desk research is briefly described including the status of the SEBCoVE project and the general framework of European CoVE initiative.
- Next, it follows a summary of the research and benchmarking carried out. This is organized in five chapters: (1) Overview of European VET and VET innovation, (2) Modern learning and teaching paradigms, (3) Teaching methodologies, (4) Educational technology, and (5) Regional and national experiences in VET innovation.
- Next, based on this information, a general analysis is provided, completed with criteria and recommendations for adoption of methodologies for the SEBCoVE VET.
- The report is closed with a summary of the work and next steps.

2. The context

This section contextualizes the research work. The objective is about identifying and recommending teaching approaches for design and provision of the SEBCoVE project's VET offer. Providing that they are feasible and show potentialities for innovative teaching and learning in the SEB sector. To this aim, the project, the overarching context, the intended VET and relevant design referents developed so far are identified and briefly described.

2.1. Innovative teaching and learning in the CoVE framework

Centres of Vocational Excellence (CoVEs) are the European initiative under the Erasmus+ funding program aimed at enhancing the quality and innovation of Vocational Education and Training (VET) systems [1].

These centres focus on creating robust networks of institutions that offer high-quality vocational training, aligned with local, regional, and European priorities for economic and social development, e.g. supporting regional "smart specialization". The core institutions are existing VET centres, delivering Initial and Continuing VET (IVET & CVET) and other services in partnership with industry, research centres, universities, and local/regional authorities.

"Vocational Excellence" means that VET has put at the centre learners and their development needs in a lifelong learning context, thrives based on quality assurance, is highly valued in the skill ecosystem, builds innovative forms of partnerships with the world of work, and is part of "knowledge triangles" (i.e. the knowledge flows between R+D, Business and University). In practice, CoVEs develop and show their "Excellence" operating across three key dimensions: (1) Teaching and Learning, (2) Cooperation and Partnership, and (3) Governance and Funding, with the EC funding support.

In the Teaching and Learning domain CoVEs are encouraged to act, among other activities, developing **innovative learner-centred teaching & learning materials and methodologies** to be adopted in vocational education pathways and programs, new or already existing. A broad frame is built for this kind of innovation with some examples:

- Including interdisciplinary, project-based, competence-based learning.

- Using "Learning factories", makerspaces and positive education.
- Making use of European competence frameworks and derivative tools such as DigComp, EntreComp, GreenComp, among others.
- Exploiting innovative teaching equipment and digital technologies such as extended reality, AI, and others for both school-based as well as WBL.
- Fostering learner excellence through actions that incentive VET learners to explore their innovation and creative potential.

Concluding, innovative teaching contributes to making technical and vocational education programs and VET systems more responsive to the integral development needs of learners as the production and labour scenarios change and socioeconomic paradigms evolve. Also, this innovation may imply new forms of CoVEs' partnerships with their stakeholders. Finally, some of the innovations suggested are coherent with the innovative traits of the training described in the granted (SEB)CoVE's proposal.

2.2. Characterization of the training in the SEBCoVE project

The SEBCoVE project, standing for Smart Electricity for Buildings (SEB) - Colleges of Vocational Excellence (CoVE), aims to develop four hubs of vocational excellence in the SEB sector (namely: Greece/Crete Region, Spain/Basque Country Region, Italy/Lombardy Region and country of North Macedonia) and constitute themselves as an international knowledge platform for this sector.

In the proposal, a major goal is the **development, testing and validation of VET for the SEB professionals** aligned with the regional and national needs researched in the beneficiary countries and the kinds of general impacts sought by the EC's CoVE initiative. This training, expectedly and more specifically, will satisfy with highly relevance, quality and innovation some important needs existing in the current VET systems. Such needs, including (Ref.: SN1-SN8 in the proposal):

- More precise information about the labour market for SEB, and prospective:
  - Features: technologies, sector & areas, labour, education, change trends.
  - Skills gaps, and future skills gaps.
  - A (European) reference framework of occupational profiles.
  - Recommendations for associated VET improvements, e.g.: curricula.
- A specific model/or "system" for providing VET programs locally (in the SEBCoVEs' regions or countries) to the targeted audiences. These

represented basically by the "electricians" that already are performing professionally, or they will, in the SEB field integrating effectively:

- Referential frameworks expressing qualifications and learning needs.
- Certification processes for acquired occupational qualifications.
- Flexible and cumulative learning pathways between qualifications.
- Up-to- date content and learning materials for digital learning.
- Flexibility and adaptation regarding the delivery of the training.
- Innovative learner-centred methods technology-enhanced.
- Collaboration with industry and other stakeholders in the skills ecosystem.
- Contributing activities, including mobilities or skills competences.
- Training of trainers and staff for delivering and managing this VET model.
- Quality assurance systems in planning and provision of this VET offering.
- Use of EU's VET standards & instruments to ease adoption.

This comprehensive training and vocational education model will be refined and developed by the consortium and significantly piloted locally by SEBCoVEs. **This training is to be called to operate as valuable evidence, or good practice, for VET improvement for the SEB sector.** Ultimately, beyond the project's end, the model will be institutionalized meaning its practical uses in forms of improvement and innovation of VET systems at regional, national and international/European level. Next, this is the basic roadmap envisaged:

1. **Reference frameworks.**
    - SEB sector research, current and future needs and priorities in VET.
    - Competencies gaps, occupational profiles, qualification levels, routes.
2. **Common curricula/programs.**
    - Flexible competency-based training.
    - Learning and certification pathways.
3. **Training design and development**
    - The training or education model for SEB.
    - Materials and resources. Learning platform for distant access.
    - Certification schemes, processes and tools.

- Quality assurance system.

4. Pilot training.

- Pilot training scope and planning.
- Preparations and adaptations for local implementations. Train trainers.
- Training implementation including certification, monitoring and evaluation.
- Revisions and reporting for disseminations.

5. Use of evidence to improve VET programs and systems for SEB.

- Disseminate evidence of good practice in the local skills ecosystems.
- Give public access to results.
- Mobilize VET stakeholders.
- Use official channels to institutionalize the model based on experience:
  - Informing policies related to the SEB sector.
  - Collaborating with authorities and decision makers.
  - Updating training offerings and occupational referents.
  - Innovate in teaching approaches and resources.

2.3. Competencies and other referents of SEBCoVE's VET

2.3.1. The SEB sector

The Smart Electricity for Buildings, or SEB, sector is used in the SEBCoVE project to refer broadly to application sectors and areas where "modern energy solutions" are used in homes and buildings, with the participation of generic "electricians" in their design, installation, maintenance and management. Such "energy solutions" assimilate to the advanced electrical installations, systems and building services that integrate into modern technology paradigms such as the "Smart Building" or the "IoT-based Smart Building". Also, "smart" refers to the "smart technology" that is particularly applied in these building solutions supported on massive data from the environment, connectivity functionalities and real-time data processing to perform some kind of digitalized autonomous task. In this way, **these evolved solutions have transformative potential to improve efficiency, comfort, safety and sustainability of buildings**. For example, Building Management Systems (BMS) are traditionally installed in large buildings for energy optimization of most consuming systems, such as HVAC. New "smarter" BMS are more capable and allow the energy optimization of the entire building.

Smart technologies for buildings applications have undergone significant development in recent years, fostered by technology providers, R+D, standardization and some favourable policies at national and European scale. To the extent, that "smart buildings" have the potential to redefine in the years to come how buildings should be designed, constructed, or managed, creating a growing demand for the kinds of skilled professionals (electricians and other occupations) capable of addressing the challenges in this evolved work environment. The SEBCoVE project is conceived to significantly contribute to meet this demand acting from the VET side.

That is, **SEBCoVE operates to identify current and future occupational competency gaps of "professional electricians" in the SEB sector to translate them into quality and innovative curricula, training offer and teaching and learning resources** potentially and positively impactful of regional/national/ international VET systems, institutions and the SEB skills ecosystems.

2.3.2. State of the Art

Starting the SEBCoVE project, the SEB sector has been researched regional/national and internationally with a diversity of goals, including: (1) Delimit the sector using the smart building paradigm where multiple building applications in the domain of energy control are integrated and managed, (2) Describe specific national/regional scenarios (SEBCoVE countries) of adoption of these (smarter) technologies in the construction sector, and major priorities and challenges, (3) Identify what technologies and building solutions are the most implemented in each one, (4) Get insights about impacts on labour and VET systems, and (5) Make comparisons seeking practical generalizations for the project purposes.

Complete information in the D2.2. *State of the Art of the SEB sector* made public and downloadable from the project's website: https://sebcove.eu/

2.3.3. Competencies and skills Gap

Considering the SEB sector and status from D2.2, another fundamental research already accomplished is about the creation of a common competencies framework for the SEBCoVE's VET. This highly representative framework, or pool of prioritized

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competencies, orientates the design of the VET offering in the project. This has been accomplished with: (1) Further research of regional/national labour markets with collaboration from SEB industry and VET providers, (2) Identification of current competency gaps (considering both sides, demands from industry and supply from VET institutions), as well as future competences gap (considering the technological sector trends or its foreseeable evolution with impact on occupations). Finally, based on this information, the SEB competencies and skills (associated Knowledge + Skills) has been selected and described.

Complete information in the *Competences and Skills Gap* (D2.3) and D7.2. Skills trends and future skills gap made public and downloadable from the project's website: https://sebcove.eu/

2.3.4. Professional profiles definition

From the competences framework above, another referent of the SEBCoVE's VET is the definition of professional or occupational profiles. These are generic occupational roles representing the kinds of qualifications enabled by the common SEBCoVE's VET offer, that associated certifications accredit. Put in another way, they represent the "advanced SEB electrician" that gives response to the prioritized competencies gaps. Strategically, a professional profile encompassing all competences defined at a EQF level 6 (i.e. engineering at a degree level, or H-VET) has been defined representing the most complete and advanced training offering and certification. Additional professional profiles have been defined coherently with lower EQF levels 4 and 5, representing lower qualification levels (i.e., technicians, or VET), and potential qualification pathways. Such pathways are the learning and certification routes that learners could choose to follow, where lower-level ones are prerequisite for higher level ones.

Complete information in the *Professional Profiles Definition* (D4.1) made public and downloadable from the project's website: https://sebcove.eu/

2.3.5. Teaching methodologies

Another relevant referent for designing the SEBCoVE's training is the teaching methodologies that this report broadly describes.

In any educational system or model, the teaching methodology informs how the education or training offerings (programs, courses, etc.) should be planned, delivered and evaluated. This is a core aspect that interacts dynamically with other functional elements. To illustrate, if curricula define what is to be taught (standards, content…), the teaching methodology defines how it should be taught. Also, the adoption of a certain methodology or approach to teaching (by decision takers in the education system) might influence a certain VET policy.

These considerations apply to the purposedly SEBCoVE's innovative VET for the SEB sector, where a trait of this innovation will come from the educational model conceived, the teaching methodology adopted, and the specific teaching methods used to teach "smart electricians" at different qualification levels.

As a referent, this Deliverable is an input, under the form of guidance, for the specific adoption of a distinctive/innovative common teaching framework linked to the training system. Later, this framework will be adapted to the characteristics and conditionings of the local implementation of the pilot training, including the selection of most convenient teaching methods and materials.

3. Research and benchmarking

In this section it is summarized the desk research and benchmarking made organized in five chapters:

1. **An overview of VET and VET innovation in the European context**. Rationale: VET systems and programs can be innovative in particular scenarios thanks to new, tested and institutionalized teaching methodologies.
2. **Current learning and teaching paradigms**. Rationale: understanding the fundamentals of how learning and teaching happens, selected teaching methodologies and pedagogical innovations increment chances of succeeding.
3. **Teaching methodologies**. Rationale: understanding the landscape of teaching methodologies and methods that apply, and that are impacting on VET systems and programs today, helps in selecting the more appropriate ones (for the SEBCoVE Project's VET).
4. **Educational technology**. Rationale: educational technology materializes or give support to methodologies and methods. Some of these methodologies, in turn, are now being impacted (adjusted, created, discarded…) in the light of emerging technologies showing high potential (e.g. AI). Successful teaching and learning innovation nowadays, in one way or another, will use both methodologies and technology, resulting in a "technology-enhanced learning".
5. **Regional and national experiences in VET innovation**. Rationale: another important source of knowledge are existing good practices and innovation experiences, particularly those close to the characteristics of the SEBCoVE's VET. These can be shared and studied as a relevant input for developing and validating the best suited methodologies and technology, with innovative traits.

3.1. Overview of European VET and VET innovation

3.1.1. Defining features of VET

In the European space, CEDEFOP [2] defines broadly VET as "**learning which aims to acquire knowledge, know-how, information, values, skills and competences – either job-specific or transversal – required in specific occupations or more**

broadly on the labor market”. And, CEDEFOP adds:

- VET covers initial vocational education and training, continuing vocational education and (not necessarily vocational) training at secondary, post-secondary and higher levels.
- It plays an increasing role in retraining and upskilling adults.
- VET can take place in a broad range of – formal (within the education systems) and non-formal (outside the education systems) – settings and – public or private – sectors.

This is a broad definition to be accepted by most countries and stakeholders. However, a multifaceted approach informs us better about the key characteristics of VET allowing comparisons. Three partly overlapping perspectives have been suggested [3]:

1. An **epistemological and pedagogical perspective**, meaning for VET:
   - A focus on practical knowledge and practical experience.
   - Varied teaching methods that emphasize application of acquired knowledge in real contexts, and interactions.
   - The reliance on specific learning and teaching models such as the “master-apprentice”, where teaching takes place in work environments promoting a direct connection between theory and practice.
2. A system and institutional perspective, that considers the scope and variety of VET programs within the education system. VET is always a very complex system with diversity of institutions, variety of programs and pathways and intersections with other educational levels. See ISCED 2011 in [2].
3. A socioeconomic and labor market perspective, where it is examined the purpose of VET in relation to entry into the world of work and adaptation to changing labor demands.

3.1.2. VET types

In Europe and other contexts (such as OECD) a basic distinction is made between **Initial VET (IVET)** and **Continuous VET (CVET).**

On one hand, CEDEFOP [2] defines IVET as learning carried out in the “initial VET system" – usually **before entering working life** – to acquire skills and competencies leading to a specific occupation or job. In addition:

- IVET can be carried out at secondary, post-secondary or tertiary level, in vocational education (full-time school-based or alternance training) or in apprenticeship models.
- It leads to a vocational qualification.
- (Although) VET undertaken after entry into working life may be considered as initial training (such as retraining/reskilling).

IVET as a supplier of young new professionals is of fundamental importance. Its modernization has long been one of the main topics across the European countries' agendas and the UE, involving study programs and actionable decisions to continuously improve its quality and responsiveness to labor market needs, and boosting attractiveness and prestige. IVET [4] covers the following **generic pathways** (Figure 1), each one with several types of programs:

- **IVET programs at secondary levels** (i.e., lower and upper secondary, ISCED 2 & 3).
- **Apprenticeships/work-based learning programs** (ISCED 2 & 3).
- **Special programs,** to assist young people at risk of being unemployed (ISCED 2 &3).
- **Post-secondary, non-tertiary education programs** (ISCED 4)
- **Tertiary education, or university levels** (ISCED 5 and above).

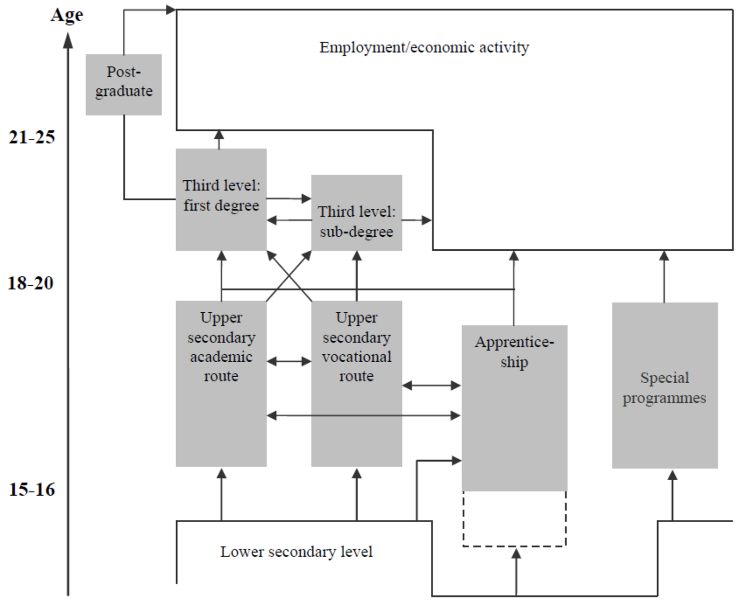

Figure 1. Generic IVET Pathways

Some common changes and trends in IVET from study of recent national reforms include the following [4]:

- Making systems more responsive to the demands of the labor market, involving the social partners and improving the means to more scientifically predict skills demands.
- A more flexible IVET system, making it easier for learners to transfer between academic and vocational routes of education.
- Increased emphasis on higher levels of skill development, signaling the relevance of postsecondary (non-tertiary) and tertiary IVET.
- Provision of greater autonomy to training providers along with orientation and support for pedagogical innovation.
- Policy is looking to make learning more flexible through several means, including the general move to modularization, competence-based training and personalization.
- Efforts aimed at promoting the vocational pathway through campaigns with provision of financial incentives to individuals & employers to engage in IVET programs.

On the other hand, CEDEFOP [2] defines CVET as learning carried out after initial education or training – or **after entry into working life** – which aims to:

- Improve or update knowledge, know-how and skills (upskilling).
- Acquiring new skills for a career move (retraining / reskilling).
- Support professional development.

In addition, CVET:

- It is part of adult learning oriented towards professional development.
- It is crucial for the employability of workers, irrespective of age, level of qualification and employment situation.
- It is an essential part of lifelong learning. Its scope and content are largely related to non-formal and informal (in the workplace, unintentional…) learning, undertaken to improve skills.
- It is delivered by a diversity of providers within and outside formal education and training, in the private and public sectors. It is often based on work-based learning.
- It covers a broad range of skills, either job-specific or transversal.

CVET remarks especially on the importance of supporting **adult people** in their lifelong learning pathways. Higher education and IVET are important but need to be complemented by CVET to deliver full educational effects on modern economics and society challenges. CVET is being encouraged, supported and improved across Europe [5] because of its potential in: (1) Employment and employability, (2) Lifelong learning, (3) Integration and inclusion, (4) Mobility and better allocation of labor, (5) Innovation, competitiveness and growth.

3.1.3. National VET systems and a common VET policy

ReferNet [6] is the network of institutions created by Cedefop to provide information on national VET systems and policies in the EU Member States and VET cooperation. From its online database, specific periodic country reports may be downloaded for a variety of purposes: characterization of national VET systems, priorities and developments, contributions to education studies, statistics or comparisons.

National VET systems are also subject to a common VET policy formulated with their participation. A glimpse of this policy is the following (more information in [7], [8]):

- Council recommendation on VET (2020). It emphasizes the modernization of VET systems focusing on flexibility, excellence, and lifelong learning to meet evolving labor market demands. It highlights the importance of digitalization, green transitions, and social inclusion within VET programs.
- Osnabrück declaration (2020). It establishes a new set of objectives for VET emphasizing resilience, excellence, and digitalization.
- Validation of Non-Formal and Informal Learning. To recognize skills and competencies acquired outside formal education, enhancing employability and motivation.
- Lifelong Guidance Policies. To ensure people, including students, workers, unemployed and other groups have access to career counselling throughout their lives.
- Quality assurance in VET Mobility. It extends quality policies long promoted in more general VET provision.
- European Skills Agenda. It sets objectives to upskill and reskill the workforce. It includes the development of micro-credentials to validate short learning experiences.
- Copenhagen process. Initiated in 2002, this process aims to enhance European cooperation in VET.
- Financing VET. To ensure VET providers can adapt to changing skill needs, including those arising from digital and green transitions.
- Sample of key instruments that support EU policies on VET modernization, mobility, and quality assurance: EQF (European Qualifications Frameworks), EQAVET (European Quality Assurance in VET), ECVET (European Credit System for VET), ESCO (European Skills, Competences, Qualifications & Occupations), Europass, Microcredentials framework.

3.1.4. Qualifications

Qualifications as job requirements are [2] knowledge, aptitudes and skills required to perform specific tasks attached to a particular work position. Formal qualifications refer to formal outcomes (in the form of titles, diplomas, certificates or equivalent) used in VET systems and others to confers official recognition of the value of learning outcomes in the labour market. So, the accredited vocational education and training that is referred to occupational competences needed by (national) industry and labour markets, constitute a traditional via to obtain formal qualifications.

Also, the European Qualifications Framework for lifelong learning (EQF) [2], [9] is the European reference tool for the description and comparison of qualifications that have been developed at national, international or sectoral level. Its eight levels of qualifications (EQF 1 to 8) are expressed as learning outcomes (knowledge, skills and responsibility and autonomy), and cover the entire span of qualifications, from those recognising basic knowledge, skills and competences to those awarded at the highest level of academic, professional and VET.

To illustrate, in the broad VET space (including HE-VET):

- EQF Levels 4 & 5 refer to qualifications for (generic) "Technicians".
- Level 4 are skilled technicians that perform practical tasks using tools, software and machinery with some degree of autonomy and responsibility over others. Whereas Level 5 are more advanced technicians, often supervising others, planning and organizing, or working with more specialized knowledge (design, diagnosis…).
- Both, Levels 4&5 are focused on building practical applications, testing, maintenance, or troubleshooting in often complex work contexts that can be intensive in interactions, or uncertain.
- EQF Level 6 refer to qualifications for (generic) "Engineers", or other degree holders.
- Level 6 is characterized by a mix of theoretical (technological and scientific) and applied knowledge, meaning that generic engineers can study, design, and manage technical projects that solve complex practical problems.
- It is possible to build logical learning and qualification pathways from lower levels to higher ones based on common competency domains and proper knowledge foundations. For different reasons (employability, etc.), the opposite also happens in IVET and CVET systems: “engineers” acquiring competences and qualifications of “technicians”.

The SEBCoVE’s VET is focused on EQF Levels 4 to 6, and the learning and professional certificates are flexible and cumulative.

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3.1.5. Innovation in VET systems

In economics, innovation refers to the development and application of new ideas, technologies, or processes that enhance productivity, create economic value, and drive growth. It is a key factor in competitive advantage and economic development. Innovation at the level of industry and sectors involves improving or creating new products, services, or production methods to increase efficiency, meet specific market demands, or gain a strategic advantage. Increasingly, in Europe it is thought that **VET can also stimulate innovation in its broadest sense**, so a certain policy of innovation has been discussed and collaboratively elaborated [10] in recent years.

The rationale is: innovation is a change factor of economy, production, labor markets and society. Therefore, it is also contributing to reshaping VET, and this requires VET itself to become dynamic and more innovative, for it can foster people's creativity and other innovators' traits useful in real-life scenarios. Further, VET needs to innovate to be a relevant and attractive education and training option for industry. In synthesis: **Innovation is a principle of VET modernization.** See in Figure 2 research findings about reasons for innovation and adopted measures.

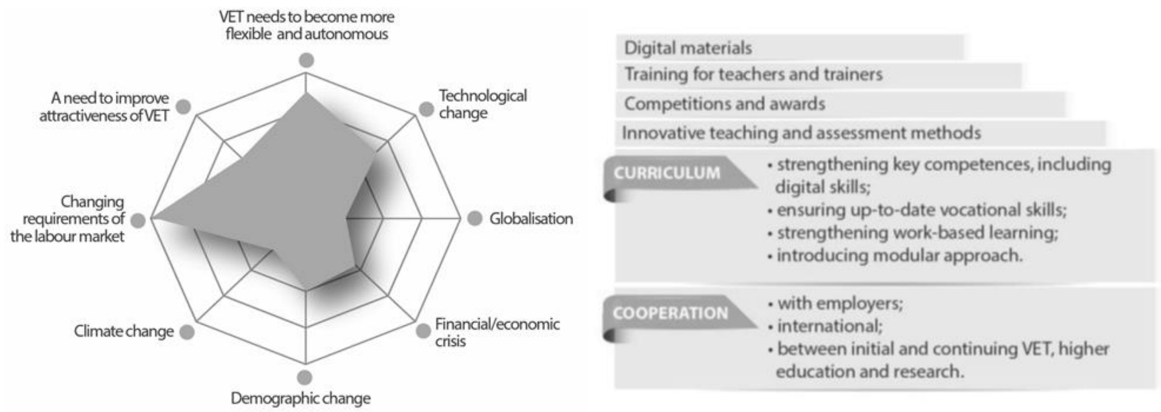

Figure 2. Reasons and types of innovation measures in VET, EU+ (2016)

Some important conclusions derived from this research are [10]:

- **Europe has not yet fully exploited its potential to encourage innovation** in enterprises and society through VET systems.
- **European VET policy should encourage innovation in VET at all levels** and in various ways, including new learning methods, use of technology or new funding mechanisms.

- **Promoting learning models (apprenticeships, internships…) at the workplace** through learning-conducive work environments provides an opportunity to bring together learning and sectors/companies' innovation efforts. Innovation can be benefited through fresh ideas and intergenerational learning.
- **Stronger cooperation**, particularly in this work-based learning, between VET institutions, higher education, research organizations and enterprises, is required.
- **New forms of cooperation must be explored**, including international cooperation.
- **And rethinking VET curricula and teaching**.
- VET curricula should incorporate **soft and transversal competences**. And a generalized move to learning outcomes (stimulated by national qualifications frameworks) that also makes learning more flexible and modular.
- Innovation also can be fostered through **organizational change** or governance change, bringing more autonomy to centers. Or with new ways of financing VET.
- Linked to curriculum development is **innovative teaching**. Group work, problem-based and project-based methodologies are increasingly being adopted.
- Also, **technology is changing VET** with generalized virtual environments for delivery of online and distant learning programs. In another example, technology allows for more personalized instruction, and innovative self-organized competence-based programs. One more example is that of advanced simulation and learning with simulators, including serious games and the application of Extended Reality (XR) technology.
- **Assessments methods can also change**, towards more flexible assessment methods and to serve the specific needs of non-formal learning validation mechanisms.
- **Competitions and awards, at national and international levels, also promote innovation.** In technical areas, in managerial or business areas, in entrepreneurship/business start-up, etc.

3.1.6. An institutional view of the innovation process in VET

Innovation in VET systems involves traditionally a structured process "top-down" oriented, like the following:

1. Needs Analysis & Strategic Alignment
    - Identify key challenges. E.g. in teaching and learning.
    - Align innovative efforts with education policies, industry trends, etc.
    - Conduct stakeholder consultations to define priorities and goals.
2. Research & Benchmarking
    - Explore best practices, research emerging models, analyze trends, etc.

4. Pilot design & Experimentation
    - Plan small-scale pilots first, to test and evaluate the innovation.
    - Train a core team of early adopters to implement the pilot.
    - Develop pilots.
5. Implementation & Capacity Building
    - Scale up successful pilots with broader participation.
    - Provide ongoing professional development to teachers and other adopters.
    - Ensure technical support and accessibility.
    - Develop materials and resources.
    - Secure funding.
6. Evaluation & Continuous Improvement
    - Collect qualitative and quantitative data from experiments.
    - Gather feedback from stakeholders: teachers, students, industry, etc.
    - Identify challenges and opportunities for further refinement.
    - Establish a continuous innovation loop.
7. Institutionalization & Policy Integration
    - Embed successful innovations into institutional policies, curricula, etc.

- Develop sustainability plans to ensure adoption (e.g., funding, incentives, etc.).
- Create knowledge-sharing communities to spread the best practices.
- Encourage collaboration with industry and policymakers to remain relevant.

8. Scaling & Dissemination

- Extend successful innovative models to multiple VET institutions, programs...
- Share findings through conferences, networks and other dissemination.
- Engage in policy advocacy to support systemic change in VET.

Notably, **in this general framework particular initiatives coming from VET Centers, networks or pedagogical teams can be accommodated**. This represents a complementary "bottom-up" innovation that, particularly, is being fostered by the European CoVEs initiative.

3.1.7. Educational models and methodology

Educational or education models refer to structured frameworks or approaches for delivering education services to given audiences, encompassing their philosophy, design, and implementation. These are generic characteristics of an educational model:

- **Foundation on educational philosophy.**
  - The theoretical principles and beliefs about how learning and teaching occur, and its purpose and orientation.
- **Societal and cultural relevance.**
  - Aligns with the values, norms, and economic needs of the society it serves.
- **Defined goals and outcomes.**
  - What learners are expected to achieve, such as competencies.
  - These outcomes align with societal, economic, cultural… needs.
- **Curriculum.**
  - Determines the content and structure of learning.

  - Including programs, topics, progression, etc.
- **Pedagogical or methodological approach.**
  - Dictates how teaching and learning occur. The guiding philosophy.
  - Including principles and models, strategies, methods, technology, etc.
- **Assessment and evaluation mechanisms.**
  - Specifies evaluation principles and how learner progress is measured and evaluated.
- **Flexibility and adaptability.**
  - Customization based on learner needs, context, available resources, etc.
  - Models of delivery. How programs will be practically implemented.
- **Integration of resources.**
  - Incorporates materials, technologies, and environments that support learning.
- **Stakeholder roles.**
  - Defines the responsibilities of teachers, students, administrators, and communities, and encourages collaborations.

The diverse pathways and typologies of programs that integrate VET systems in general can be seen as **distinctive educational models** operating within. For example, apprenticeship programs respond to an overarching model that offers a structured, experiential, and competency-based framework that makes it a relevant educational approach within the VET system.

3.1.8. Delivery models.

Delivery models inform about organizational and logistical structures that in essence determine where, when, and how learners access training. In the general VET space, these ones are relevant:

- **Presential (or Face-to-Face).** When learning happens in a classroom, workshop, lab... with the presence of teachers, instructors, coaches, etc.
- **Online learning**. When learning happens supported on some sort of digital platform remotely accessible (internet) where content is stored, with learners and teachers differently located than can communicate each other both asynchronously (e-mail, etc.) and synchronously (a virtual classroom).

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Regarding organization, online learning may also be individual and self-paced.

- **Distant learning**. It is the broad concept used to refer to modes of education where learners and instructors are physically separated relying on diverse means of communication. In online learning these means refer to the internet, but still there are others in use, such as TV/radio (broadcasted) or correspondence. Often, self-paced.
- **Blended or Hybrid learning**. When learning happens in an optimized mix of online/distant and face-to-face components.
- **Work-based learning (WBL).** CEDEFOP [1] defines WBL broadly as an “instruction model” (education model) in which the learner acquires knowledge, know-how, information, values, skills and competences carrying out – and reflecting on – tasks at the workplace or in a simulated work environment, under the guidance of experienced workers or trainers. Also, WBL can be seen as a distinctive delivery model when learning in a real work context (or in a “high-fidelity” simulation of the workplace) is introduced complementarily or alternatively to learning in a “school-based” context. For example, in apprenticeships, internships, dual models, etc.
- **Microlearning/(Mobile Learning).** It refers to short, targeted learning (very short courses, modules, units, lessons, etc.) via mobile apps, quick video tutorials, “learning pills”, and the like. It has been used most in non-formal and informal training (on-the-job training and lifelong learning for continuous upskilling, knowledge refreshers, just-in-time assistance for workers, etc. Also, in peer-learning and communities of practice, MOOCs and in some training services). But microlearning has a role in formal VET, too. Not as a replacement, but as a supplementary learning in larger models such as blended or hybrid learning. For example, as “pre-class materials” within an “inverted teaching model” (Flipped/Inverted classrooms where learners independently learn the foundations and basic exercising out of classroom). Also, as assessment support, etc.

In conclusion, VET systems (although not exclusively), benefit from **integrating multiple education models** to address the diverse needs of learners and the multifaceted goals of the education service. This approach ensures inclusiveness, adaptability, and relevance, making education more effective for all stakeholders. Relevant takeaways:

- Education models influence teaching methodology.
- Education models (and some teaching methodologies) may be planned and organized for different delivery models.

3.2. Modern learning and teaching paradigms

3.2.1. Learning perspectives

A premise is that, if we want to help people learn, it is helpful to understand how learning works. But learning is a very complex process that cannot be fully described using a sole theory, yet. Instead, many perspectives are taken, and many more learning facets are studied and integrated, from which learning explanations are derived. All of this can be scientifically tested and later translated into teaching practices. This "teaching informed by science" is completed with several philosophies and frameworks of learning.

These are some learning theories with application to education and training scenarios in general, for young and adult learners. Basic references in [11], [12], [13]:

- **Cognitivism.** Focus on how learners process content, modulated by prior knowledge, metacognitive control and motivation, producing new knowledge in the form of mental models that enable (intellectual, motor, attitudinal) performances.
  - Application: frameworks and models of explicit/direct instruction.
- **Constructivism/(or Inquiry Learning).** Focuses on how people create knowledge as they attempt to understand their experiences. So, they actively build their own understanding.
  - Application: Inquiry-based teaching models, e.g. PBL.
- **Social learning**. Focus on how people learn by observing others with modeling, imitation, and social reinforcement processes.
  - Application: on-the-job learning models, mentorships, role-playing.
- **Situated learning**. Focus on how learning happens as an activity embedded in real world contexts, connected with real situations, environments, and social interactions.
  - Application: Learning communities, Internships, Projects with industry.

- **Socio-constructivism**. Integrate several theories to explain how knowledge is constructed, not only individually, but also shaped by social interaction, shared experiences, language, etc.
  - Application: Constructivist learning environments, Collaborative learning.
- **Behaviourism**. Focus on how learning happens by producing observable changes in behavior, driven by stimuli, responses, and reinforcement.
  - Application: skill-based training (as in sports or craft skills), drills, behavior change.
- **Experiential learning**. Focus on how learning is achieved through experience (learning by doing) and reflection.
  - Application: Hands-on labs, internships, simulations, etc.
- **Meta-learning & Self-regulated learning**. Focus on metacognition, or awareness and control of their own cognitive processing and learning.
  - Application: study strategies, adaptive learning platforms, analytics.
- **Motivational.** Focus on how motivation (goal-directed behavior) influences learning.
  - Application: engaging learners and sustaining the mental effort for learning.
- **Connectivism** [14]. Focus on how learning occurs via connections to digital networks, social interactions, and technology where information & knowledge are distributed.
  - Application: E-learning, MOOCs, collaborative online platforms, etc.
- **Transformative learning** [15]. Focus on how learning leads to fundamental shifts in understandings or worldviews.
  - Application: reflective learning and critical thinking programs, leadership training.
- **Learning in subject areas**. Focus on the study of how people learn academic subjects, resulting in the psychologies of math, sciences, languages, reading, sports, etc.
  - Application: specific models for enhanced the training of adult people in job-related competencies and settings: technical, managerial, soft/generic skills…

- **Learning philosophies**. Not a theory. They are broad, foundational belief systems that shape how knowledge, the learning process, or education are understood. Example: objectivism, pragmatism and interpretivism are coherent with behaviorism, cognitivism and constructivism (not exclusively).
- **Learning frameworks**. Not a theory. Still, they are centered on learners. They gather and organize principles from existing learning theories to guide some type of learning outcomes. Some examples:
  - Competency-based learning. Generically, it is focused on the application of acquired knowledge, skills and attitudes (complex knowledge) to real-world situations, such as acquiring demanded entry-level occupational competencies in VET programs. Around this first principle, learner-centered teaching & learning environments are created.
  - Socio-Emotional Learning [16], focus on how learning is connected to social and emotional skills, like self-awareness and emotional regulation, for better performance in academic settings, behavior, etc.
  - Gamification [17], where game-like elements (e.g., points, badges, leaderboards, challenges, etc.) are applied to non-game environments, such as technical training, to increase motivation, engagement, and certain learning outcomes.
  - Simulation-based learning [18], where realistic, interactive and immersive environments (physical, digital, virtual) are used to enable learners to safely practice skills before applying them in real-world situations and resources.
  - Andragogy [19], as a framework for structuring adult learning experiences based on learning principles and preferences that, is believed, characterize them.
  - Many others, including own learning frameworks or philosophies.

Concluding, the sciences of learning seek to create a research-based theory of how learning works that may/should inform teaching. Some of the learning perspectives above would share a common/traditional interpretation of **learning as a change in knowledge attributable to experience** (from a cognitive view, [12]). This definition has three parts:

(1) Learning involves a lasting change in the learner (e.g. learn to write code).

(2) What is changed is the learner's knowledge, that is not directly observable but can be inferred from behaviour (e.g. a functional piece of code has been created).

(3) The cause of the change is the learner's experience (e.g. reading the programming manual, attending classes, practicing in the IDE).

But other learning perspectives are challenging this interpretation showing its limits/lacks in current learning scenarios (e.g. network-based learning from connectionism). Teaching innovation can adopt many forms and is dependent on context. Perhaps, in a particular learning scenario, the innovation involves exploring the applicability and efficiency of a new learning view.

3.2.2. Teaching paradigms

Teaching paradigms can be defined as broad frameworks or models that shape an educator's approach to teaching which is understood as **learning facilitation** for some type of learning outcome and audience. They encompass fundamental beliefs about how learning occurs and the nature of knowledge (learning perspectives), the purpose of education and how this should be designed. So, teaching paradigms inform overall teaching approaches and guide high-level decision-making. Perhaps, more than one teaching model/methodology, understood as more specific practices, is necessary to implement a particular teaching paradigm.

Following, a list of relevant teaching paradigms, **from the VET and adult learning** sides. Basic references in: [11], [20], [21].

- **Holistic Learner-Centered Teaching (Holistic LCT).** [22] This is an overarching paradigm widely used in current educational policy, including European VET policy. It is characterized by the shift of the focus from the teacher to the learners with an “holistic” approach, to develop “well-rounded” individuals who can apply their learning in real-world scenarios, like job. Holistic means that the “whole learner” is considered (not only knowledge or skills) recognizing that learning is influenced by multiple factors (including, social, emotional, practical, etc.). In VET this is represented in explicit guiding models of professionalism. It is rooted in a diversity of sources, including learning theories, social sciences, philosophies and much more. It emphasizes:

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- Learning beyond just knowledge. That is, complex knowledge and practical application in real contexts, involving “higher-order thinking” (critical thinking, problem solving, decision making, social skills, etc.).
- Real-world relevance. Use of authentic, meaningful learning experiences.
- Personalized and adaptive learning. Flexible teaching methods based on technology. Focus on learners’ strengths, involving self-exploration.
- Integration of cognitive, emotional, and social development. Learning involves motivation, collaboration, emotional intelligence, personal growth.
- Encourages lifelong learning. It develops self-directed learners, adaptability and a growth mindset. It gives students some control over their own learning process. “Learn to learn”.
- Active student engagement in their own learning and associated effort.
- Reflection and metacognition. Self-awareness.
- Teacher as facilitator, and not the only source of information.

- **Competency-Based Learning (CBL).** This model aligns with LCT’s principles, and it has been universalized in VET systems and offers. In CBL teaching is oriented to competencies acquisition as aggregations of complex knowledge that enable valuable performances in real-world scenarios. Such as occupational skills in VET qualifications and programs. Here, some distinctive features are:
  - Clear learning expectations: competencies and performance indicators.
  - Learning outcomes endorsed by stakeholders, which can co-participate in the training in a diversity of ways (such as in “dual models” of VET).
  - Application of acquired knowledge. Individual and collaborative ways. Real or highly realistic.
  - Seeks flexibility in the provision of teaching, learning routes, etc.
  - Seeks adaptations in learning. Personalized learning.
  - Favor a mastery-based progression based on independent and cumulative competencies meaningful by themselves.
  - Meaningful assessment: criterion-referenced or standards-based.
  - Learners’ agency. Decisions about their own learning, participation, etc.
  - Focus on lifelong learning skills (e.g. entrepreneurship skills, etc.).

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- **“Learning-by-Doing” or Experiential Learning.** This teaching paradigm is also widely applied, although it can be seen included in even broader ones, such as CBT in VET. It represents a shift from traditional classroom-based instruction to a more hands-on, active approach to education. Understandably, it aligns with VET’s emphasis on skill mastery (over theoretical, cumulative knowledge). It is rooted in: Situated Learning, Experiential Learning. Some emphases are:
  - Active student engagement in practical experiences.
  - Learning from mistakes in controlled environments before transfer.
  - Application of knowledge to real-world situations.
  - Development of critical thinking and problem-solving skills.
  - Reflection on the learning process.
- **Work-based Learning (WBL).** WBL can be seen as many different things: as a teaching model, a delivery model and an educational paradigm, too. As a teaching paradigm, it represents a shift from traditional classroom-based instruction to a more experiential and applied approach to learning, where knowledge is (primary or complementarily) acquired and reinforced in the workplace. It is inspired by the (pre-formal schooling) tradition of “master-apprentice” relationships. The actual intent is to provide learners with more and better chances of “experience acquisition” (e.g., work relationships, values, ethics…, employability skills), before entry to work. The nuances of this enhanced learning cannot be acquired only with classroom-based instruction. Rooted in: Situated Learning, Social Learning. Other features are:
  - Integration of theory and practice. Relations with learning by doing, CBL…
  - Real-world relevance in education.
  - Development of employability skills.
  - Active engagement with industry professionals.
  - Personalized learning experiences in the workplace. Mentorships.
  - Multiple versions/models of WBL: apprenticeships models, internships, dual education models, job Shadowing, participation in industry/business projects, etc.
- **Simulation-Based Learning/Scenario-Based Learning.** [18], [23] In this paradigm, realistic, risk-free ways to practice complex tasks are provided

before transferring the acquired skills to the real systems and settings (real tools, machinery, manufacturing contexts, vehicles, service contexts, etc.). It allows for repetition and mastery without resource constraints, and it supports training in hazardous or high-risk fields. It is based on traditional physical and computer-based simulators, as well as modern virtual simulators (XR), serious games, etc. Rooted in: Experiential Learning, Cognitivism, Behaviorism, Constructivism.

- **Inquiry-Based Learning.** In this teaching paradigm, critical thinking and independent problem-solving are encouraged. It helps learners to develop higher-order skills (such as diagnostic skills in VET scenarios). Prepares learners for complex and unpredictable workplace challenges. Project/Problem/Challenges-Based Learning or industry-driven problem-solving tasks are common teaching methods. Rooted in: Constructivism, Socio-Constructivism.
- **Gamified Learning** [17]. Under this framework, learners' engagement and motivation are considered relevant aspects for learning, especially in digital training environments. It encourages self-paced learning and competition (against others or oneself). Also, it makes complex learning more interactive and "immersive/realistic". For example, serious games used in business (business simulators), or XR training with gamified challenges. Rooted in: Behaviorism, Constructivism, Cognitivism, Motivation theories.
- **Teacher-Centered Learning (TCL).** [24] [25]. This is another extremely broad teaching paradigm, also known as "traditional teaching", and many times described as the (negative) opposite to LCT and thus of relatively little value in VET. This is due to a misinterpretation that uses reductionist views (lecture-based teaching, memorization methods, no relevant practices or skill-based, etc.). It is rooted in: Cognitivism, Metacognition, Motivational and observation of most successful teaching practices in real settings. On these bases, several "cognitive" approaches to teaching and models are derived, often classified as "direct teaching" or "explicit teaching". Common characteristics of these approaches are:
  - Based on an "information-processing paradigm" that takes into account the characteristics and constraints of the cognitive architecture during

learning (Attention, Memory, Processing, Prior learning, Schemas, Retrieval, “experts” vs. “novices” thinking, Cognitive Load, etc.).

- Highly structured.
- Basic learning cycle for significant learning consisting of: activation for learning, information and demonstration from the teacher/system, practice with relevant feedback from students and integration or knowledge application (or far transfer).
- This learning cycle receive high support (scaffolding, minimalist training, worked examples before problems, etc.) from the teacher/system starting the process, and progressively is removed as learners make progress in their learning sequences (lessons, modules, courses…).
- Also, this learning cycle is elaboratively presented (based on prior learning) or organized according to other logics. For example, task/problem/scenario-based with progressively complex challenges.
- Many other teaching paradigms draw elements from this (cognitive) approach, to build more complete and robust models.

We can apply what we know (and believe) about learning to create teaching that promotes intended learning outcomes. Thus, teaching is basically the teacher’s attempt to promote a change in the knowledge of the learner, identifying teaching approaches and methods and determining whether, when, and how they work (this is the science of teaching). More precisely, teaching is, in essence, **the teacher/(system) manipulation of the learner's environment to foster learning** [12]. This definition has two main parts:

(1) Manipulating what the learner experiences. This is to say, materializing a teaching strategy or method. For example: demonstrating how a professional tool is used.

(2) With the intention of causing a change in the learner's knowledge. For example: understanding the technique before practicing it.

Teaching innovation can be oriented to, in general, getting more effective, efficient and engaging teaching programs by incorporating new or improved teaching frameworks and coherent methodologies.

3.2.3. Teaching design

Teachers, instructors/trainers, instructional designers and other specialists plan systematically their teaching actions (sessions, lessons, modules, courses, study materials, etc.) before implementing them. Often, they use more or less flexible frameworks (models, processes, templates… external/standard, or internal/tailored) coherent with the teaching approach chosen or prescribed (e.g. an institutional one from the education systems in the form of an "educational philosophy"). See, for example, [25]. The important point here is that **the adopted teaching paradigm influences how teaching design and development should be approached**. Of course, an important part of the teaching planning at any level ("lesson", "module" or "course" level), for teachers and other agents, consists of selecting proper teaching methods and methodologies. This is a core competency in competency frameworks for teachers and instructors. See, for example, [21].

3.3. Teaching methodologies

3.3.1. Definition and classification

From previous sections, it is understood that teaching methodologies are broad teaching approaches/frameworks that guide how certain learning can be facilitated. Often, it is confusing to discriminate between close concepts, such as education models and methodologies, or between different ideas named equal, such as Competency Based Learning that is commonly used to designate a learning framework (i.e. complex learning that enable performances in real-world contexts), an educational model (i.e. structured models of instruction) or even a teaching methodology (i.e. how teachers will organize their lessons and assessments toward these integrated learning outcomes). To clarify, when it comes to discussing teaching methodologies these are generic concepts often involved, and their basic relationship:

Learning Framework → Teaching/Education paradigm → Education Model → Teaching Methodology → Teaching Methods & Techniques

- Learning Framework. The high-level perspective on how learning happens, build on learning sciences, other contributing disciplines, and beliefs.
- Teaching Paradigm. Theoretical stance on how teaching should be approached to facilitate certain learning outcomes in certain groups of people.
- Education Model. A structured implementation of a teaching paradigm or approach, often framed in an education system.

- Teaching methodology. The broad instructional approach within a certain teaching model.
- Teaching Method. Specific procedures that implement the methodology.

The task of classifying teaching methodologies (and methods) is also a very complex one [26]. On the one hand, they can be examined in the light of their theoretical foundations (teaching paradigms or frameworks) giving place to both general (e.g. promoting learning in any teaching scenario) or highly specific methodologies (e.g. how to learn languages). Besides, they are to be tailored to the specific teaching and learning situation, resulting in multiple variations. On the other hand, methodologies and methods are subordinated to the intended learning outcomes. These, broadly (any content domain), can be classified as **Understandings, Skills, Affective and Integrated** [30]. In conclusion, methodologies can be broadly classified according to:

(1) The teaching approaches (theoretical foundations).

(2) The type of learning outcomes (Understandings, Skills, Affective, and Integrated).

3.3.2. Methodological approaches for different learning outcomes

In this section, methodological approaches are briefly characterized for fostering Understandings, Skills, Affective and Integrated learning outcomes.

Fostering Understanding outcomes [26][27][28][29][30]. Taken in its broadest sense, understanding can be equated to a "basic performance capability" to signal that learners that understand content can grasp and relate basic meanings and use this knowledge in a range of circumstances, including some practical situations (near transfer). This implies significative learning. Also, this content refers not only to conceptual information, but also factual, procedural, conditional and bodies of information that usually make study topics. So, this "understanding" can be seen as the foundation for further learning and more valued performances in a course, or similar. To clarify this, a learner can:

- Use memorized facts about how to approach a certain task, or about the tools and materials involved, for providing guidance to a simulated customer.
- Use learnt parts and basic functions to describe structurally a given system.
- Use learnt principles and theories to basically explain, calculate or predict the functioning and responses of a technical system.

- Compare two learnt ways of building something, including associated conditional knowledge, to reason about the best suited in a given context.

A broad methodological approach to facilitate these sorts of learning outcomes is:

- Select the topic, analyze and plan delivery. Including facts, concepts, principles and theories, procedures or combinations. Some will be prerequisites for others. Select proper methods to teach facts, concepts, principles and procedures.
- Introduce the topic and understanding goals. Connect with prior knowledge and emphasizes relevance of the entire topic.
- Tell and demonstrate understanding goals involved, and practical uses.
- Promote effective performances with proper exercising and practice.
- Track, assess, feedback and improve learning.
- Apply practically the acquired knowledge. Go beyond (transfer, integrate).
- Engage learners in reflective, collaborative communities.
- Use proper technologies in each learning stage.
- Use a motivational approach to capture, sustain and strength interest.

This framework must be instantiated according to the type of content at hand. For example, conceptual content (concept, principles, etc.) can be learnt by elaborating on previous simpler versions of the theory with the help of technology, such as modeling software with which learners can actively test, construct meaning, predict, etc. Other general methods include:

- For factual content: drill& practice, games, chunking and categorization, learning embedded in narratives or in context, etc.
- For conceptual content: Lectures, analogies, questioning and discussion, inquiries (guided discovery), experiments, collaboration, problem solving, etc.

Fostering Skill development outcomes [26][27][28][29][30]. Skill is defined as the capacity to perform a given type of task or activity with a given degree of effectiveness, efficiency, speed or other quantity or quality measure. Two basic types of skills are motor/physical and cognitive/mental skills. These in turn, can be classified in other practical ways from the point of view of teaching. For example, motor skills can go from simple movements to highly complex coordinated ones. And mental skills can go from highly structured procedures (algorithmic, based on fixed sequences of steps) to ill-structured strategies (heuristic, based on principles with no guarantee of results). To clarify:

- Using professional hand tools with dexterity and efficiency is a motor skill.
- Estimating the total consumption of energy of a home is a procedural skill.
- Troubleshooting a faulty system is (often) a moderately structured skill.
- Configuring an adaptive defense strategy for a digital connected system against unknown vulnerabilities (cyber-attacks) is an ill-structured skill.

Essentially, any skill is learnt and taught similarly through these stages:

- Acquire understandings of what is to be done, e.g. the steps and order to do something, principles involved in problem solving, context, etc.
- Execute actions, e.g. practice steps, sequences, from simple to complex.
- Transfer control and automatize, e.g. tune the steps with practice, increase complexity, automatize routine elements.
- Generalize the skill. e.g. mastering the skill to the standards that apply (proficiency). Learn more conditional knowledge: what, when, how.
- Use timely and informative feedback all the process long.

Again, each of these types of skills deserve their own teaching methods. For example, a troubleshooting procedure can be learnt progressively based on system simulators with random fault-generating capacities; also, engaged in real well-planned troubleshooting activity. Other general methods include:

- Demonstration and modeling.
- Step-by-Step Instruction. Elaboration: from simple to complex versions.
- Guided practice and repetition. Spaced practice and retrieval.
- Hands-On training or experiential. Real or simulated.
- Scaffolding and gradual remove of support.
- Role-playing & simulations.
- Checklists and procedural guides.
- Peer coaching & collaborative Learning
- “Error-based” Learning. Fail and analyse what was wrong and why.

Fostering Affective development outcomes [26][29]. The affective domain of learning refers to the value-based, attitudinal, motivational and emotional aspects of learning. It involves how learners feel and respond towards the learning content, and beyond.

On one hand, Attitudes are “reactive skills” meaning forms of reacting to things, activities, situations or people. They are expressions of values in specific situations, e.g., a positive attitude toward teamwork in the workplace reflects the value of collaboration in this real scenario. Attitudes are learnt when both the expected behavior (how to react) and the affective component (choose to react in the proper way because this way is known and valued) are learnt. This is accomplished basically by exposure, reinforcement, and practice. See more in detail this process with examples of generic methods:

- Awareness and exposure. Learners are introduced to different perspectives, values, and ethical considerations through discussions, case studies, etc.
- Modeling and demonstration. Teachers, trainers, or mentors demonstrate the desired attitude through their own behavior (e.g., showing professionalism, teamwork, or empathy).
- Experience and engagement. Active participation is encouraged in activities like role-playing, simulations, debates, simulated tasks or group projects where attitudes are tested, assessed and developed.
- Feedback and reflection. Teachers provide constructive feedback and create opportunities for learners to reflect on their shown attitudes and behaviors.
- Reinforcement and practice. Repeated exposure to real-life situations helps internalize attitudes, making them part of the learner’s long-term behavior.

For its part, values are deeply held beliefs or principles that guide a person's attitudes, decisions, and behavior in general, reflecting what is considered important or desirable in the scenarios of life, including work. They take a long time to develop and are learned through socialization, experience, and reflection. See the process and some methods:

- Observation and imitation. Role models (like teachers, professionals, mentors…).

- Experience and interaction. Engaging in the real to shape values through real-world consequences.
- Education and discussion. Ethical and moral debates, exposure to perspectives, etc. to deepen understanding.
- Personal reflection. Internalize values by evaluating their own beliefs and experiences.
- Reinforcement. Rewards, recognition, feedback…, reinforce certain values, making them more likely to be adopted.

Also, emotions matter in learning because they influence motivation, attention, processing, or decision-making. Positive emotions (e.g., curiosity) enhance engagement and retention, while negative emotions (e.g., anxiety, frustration, boredom) can hinder learning. Although not easily, as in the case of values, learners can develop so-called “emotional intelligence” including:

- Self-awareness. Recognizing and understanding one’s emotions.
- Self-regulation. Managing emotions effectively in different situations.
- Empathy. Understanding and responding to others’ emotions.
- Social skills. Communicating & collaborating effectively, with emotion mgmt.
- Emotional resilience. Coping with stress, failure, and setbacks.

All this is generically promoted using supportive learning environments that foster positive emotions, with proper feedback mechanisms that encourage reflection on emotional responses and some methods such as case studies, using immersive scenarios that simulate real-world emotional challenges (e.g. handling workplace conflicts), and through reality such as in WBL models.

Finally, motivation is an internal state that initiates and maintains goal directed behaviour. It is also an affective goal because it involves emotions, attitudes, and values that drive learners to engage with and persist in the learning tasks. Motivation is a very complex process comprised of multiple interactive ones. To illustrate, it can be based on:

- Interest. The personal value that the training has (e.g. “I like this”).
- Beliefs. Believing the hard work pay off (e.g. “I’m really good at this”).

- Attributions. Successes or failures are attributed to effort (e.g. “I must persist and work harder”).
- Partnership. The learner feels part of a team (e.g. “Together to learn this”).
- Goals. The learner put effort on learning clear goals (e.g. “I have to learn this”).
- Counterintuitive findings. Learning success acts as an activator of motivation which in turn translates into more learning effort. So, during training students should feel they can cope with the material and develop a self-sense of progress and mastery. This can be more effective than trying to motivate them in advance. Excessively complex challenges are not motivating.

Fostering Integrated Learning Outcomes [25][26]. Competence can be seen as complex knowledge combining understandings, skills and affective elements, along with other generic knowledge and cumulated experiences, that can be flexibly and creatively mobilized to address the problems in a domain to the standards that apply (technical quality, behavior, safety, etc.). This kind of knowledge takes time to acquire and, as in the case of occupational competencies, it is better learnt through holistic approaches. To clarify, the general strategy can be described like this:

- Analyse the performance goal to know/select their scope and main componential knowledge involved, and an effective learning roadmap.
- Identify representative types of problems/challenges, tasks, scenarios, cases, projects, themes, etc. Organize them in a sequence from simple to complex.
- Analyse specifically the problems/challenges or classes of problems to know their knowledge requisites, and others (resources, approaches, etc.).
- Organize (plan, develop…) instruction (course or modules) around the sequence(s) of real-like (or real) problems or tasks chosen. Using, for example, a problem-based methodology.
- For each (class of) problem, teach accordingly “strategic knowledge” and more “instrumental or routine” one in context (lessons or sessions involved…). Strategic knowledge is different in each problem situation (e.g., critical calculations, analytical skills, principled actions, etc.), whereas routine knowledge is stable, procedural and can be automated with practice (e.g. use a hand tool or an Excel sheet, follow routinary safety rules, etc.).

- For each class of problems, give support and feedback, modulated by students' experience and learning progression. High support starting, and no support finalizing the learning sequence, and in assessments.
- Promote also collaborative learning and self-directed learning.
- Use "authentic" assessment methods criterion-based.
- Make learners and teams accountable of their work processes and results, going public, demonstrating accomplishments, reflective reports about the work done, portfolios, formulating improvements, etc.

This scheme is essentially coherent with an even more challenging learning enterprise. This is learning across domains or multidisciplinary learning. It is the theme-based learning in academic contexts based on different contributing subject matters or disciplines (e.g. social or environmental sciences for a technical challenge with social impacts, for example). In traditional modular VET scenarios school-based, this is accomplished by integrating several (units of) competencies of the occupational role around a complex project. Or, perhaps more effectively, through the involvement in a real industry project within a WBL model.

3.3.3. Methodologies for different teaching approaches

In this section, these methodologies often used in VET programs, are characterized: Project Based Learning, Task-Based/Whole Task-Based Learning, Scenario-Based Learning, Simulation-Based Learning, Collaborative Learning, Case-Based Learning, Problem-Based Learning, Flipped Classroom methodology, Competency-Based Learning, Work-Based Learning and Serious Games and gamification.

All of them are broad guiding frameworks for facilitating structurally and systematically some types of learning outcomes. Many other close pedagogical constructs may contribute without being full methodologies. For example, delivery models, learning and teaching paradigms, learning environments and technologies, transversal learning strategies, etc. For example, "maker spaces" or "fab labs" are learning environments more than methodologies. Also, mobile learning, or just-in-time learning, are delivery models and not methodologies. Also, as it already has been said, the same concept can be interpreted in different ways: as a model, a methodology, a method, etc.

Project Based Learning (PjBL) [31]. This methodology is an active learning approach where learners engage in complex real or realistic world projects oriented to tangible results in the form of products and activities. Using and developing technical and managerial knowledge, problem-solving skills, soft skills and creativity.

- Distinctive features:
  - Focuses on inquiry-driven, systematic hands-on learning.
  - Requires the application of diverse and integrated knowledge.
  - Encourages collaboration, technical communication, critical thinking.
  - Learners study technical challenges, pose solutions, develop and test prototypes of tangible products and services, defend their solutions and reflect on results and the process.
  - May involve multidisciplinary or distant collaborative teams.
  - This happens in simulated or entirely real need scenarios.
- Learning outcomes
  - Develops innovation, problem-solving, analytical and creative skills.
  - Strengthens teamwork, collaboration, leadership, management.
  - Encourages self-directed learning and adaptability to contingencies.
  - Enhances technical expertise in project-relevant fields.
  - Often, requires going beyond (of the existing skills and knowledge).
  - Provides opportunities for far transfer (competency development).
- Examples:
  - Electricity: configure and install a commercial solar PV system.
  - Entrepreneurship: develop a business plan linked to a business idea.
  - Cooking: prepare and serve meals for a group or invited teachers.
- Associated technologies:
  - Collaborative tools.
  - Prototyping, CAD and simulation software.
  - Cloud-based project management platforms.
  - Professional tools, real equipment, materials and documentation.
  - Maker spaces (for prototyping, research, etc.).
- Challenges, limitations for adoption:
  - Time-consuming. Hard to plan, sustain, manage, assess.
  - Often, the project is a unique experience in a long course.
  - Uneven team participation.

Task-Based Learning (TBL) and Whole-Task Learning (WTL) [24]**.** In TBL, learning is organized around relatively small and cumulative tasks towards complex occupational skills or competences. It's based on an analytical approach. These tasks are usually shorter, more structured, and focused on mastering specific skills and knowledge before using them in full realistic or more challenging projects. In WTL, the analysis is not primarily focused on skill components, but in application versions of the complex skill. Then the training is elaboratively organized from the simpler to the complex versions. So, TBL can be subsumed in a PjBL methodology to acquire "partial knowledge", and WTL can be seen as a general version of PjBL, perhaps more structured.

- Distinctive features:
  - Step-by-step skill acquisition. Aggregation. Repetition & mastery.
  - Real-world relevance. Clear assessment criteria.
  - Scaffolded learning. Tasks increase in complexity, leading toward full/complex project execution or the most complex tasks.
  - (WTL) Organizing tasks represent real work. Starting with the easiest cases. Allows for multiple tasks or classes of tasks in a course.
- Learning outcomes:
  - Develops practical occupational skills.
  - Enhances efficiency and precision in work tasks.
  - Prepares learners for real-world workflows and larger projects.
- Examples:
  - Culinary arts. Learning culinary and cooking techniques. Prepare dishes.
  - Welding. Develop progressively difficult welded structures.
  - Automotive mechanics. Learning servicing tasks of car or truck.
  - Electricity. Develop progressively difficult lighting installations.
- Associated technologies:
  - Professional tools, materials and machinery.
  - Physical training kits, laboratories, workshops, etc.
  - Advanced simulators.
- Challenges, limitations for adoption:
  - Risk of excessive task fragmentation and decontextualization.
  - Risk of demotivation is routinary skills are decontextualized taught.

Scenario-Based Learning (SBL) [23]. This teaching methodology places learners in realistic, context-rich scenarios where they must make decisions and solve problems. Often, it is based on advanced technology. It focuses on situational awareness, decision-making and problem-solving.

- Distinctive features:
  - Uses story-driven and real-world-based challenges.
  - Some, focus on soft skills, ethical dilemmas, leadership, interactions.
  - Some others are structured around problem-solving, diagnostics, etc.
  - Learners work individually or in groups.
  - Can be linear (fixed path) or branched (multiple pathways and consequences).
  - Provides safe, risk-free environments for practicing critical decisions.
  - May integrate role-playing, interactive media, and AI-driven simulations.
- Learning outcomes
  - Social skills, decision-making skills, problem solving, diagnostics, etc.
  - Enhances critical thinking in general and performance under uncertainty.
  - Improves communication and teamwork, in high-stakes environments.
  - Helps learners apply knowledge in, often, school-based settings.
- Examples
  - Business: crisis mgmt. simulations to decide on optimal strategies.
  - Cybersecurity: interactive training to respond to a security breach.
  - Engineering: immersive VR scenario where users inspect structure and operation of a complex industrial system, identify wear and tear, and make decisions on component replacement.
- Associated (ed.) technologies:
  - AI-driven branching scenarios.
  - XR technology (VR, AR, MR).
  - Gamified interactive platforms.
  - Learning Management Systems (LMS) with adaptive pathways.
- Challenges, limitations for adoption:
  - Resource-intensive. Extensive planning and development. Expensive.
  - Limited technical skills (hands-on practice) application.
  - May not fully replicate real-world unpredictability.

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Simulation-Based Learning (SimBL) [18]. This teaching methodology uses interactive digital or physical models to replicate real-world systems (with different degree of fidelity, depending on the learning outcomes or training stage), allowing learners to practice skills and problem-solving in a realistic, risk-free environment. These simulators do not substitute the work with the real system as part of the training but reduce required time on the real systems, ensure safety and save money.

- Distinctive features:
  - Hands-on interaction with simulated systems (virtual or physical).
  - Can simulate physical laws, system behaviours, malfunctions, etc.
  - Provides real-time feedback on performance, and data for training mgmt.
  - Allows repeatable, standardized training (important in regulated jobs).
  - Useful for high-risk environments (e.g., aviation, manufacturing, medical).
- Learning outcomes:
  - Enhances technical skills, promotes procedural knowledge.
  - Improves system diagnostics and troubleshooting skills.
  - Helps learners acquire technical skills, in almost their scope.
  - Prepare learners for performing with the real system and real context.
- Examples:
  - In general: physical (electronics, mechanical… systems), software (circuit simulators, physics-based, etc.), virtual (immersive) simulators.
  - Aviation: flight simulators for pilot training.
  - Electricity: training panel for building automation.
  - Manufacturing: digital twins of systems for testing, diagnosing, repairing.
- Associated technologies
  - XR technologies.
  - Physics-based simulation engines in software simulators.
  - Physical simulators for analysis, constructive or maintenance skills.
- Challenges, limitations for adoption
  - Can be an expensive technology. For example, high-quality XR simulators that require real-time processing, collaborative features, connectivity, etc.
  - Not always transferable to real-world execution.
  - Not intended, for soft skills training.

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Collaborative Learning (CL) [31][32]. Student-centred methodology where learners, in general, work together in small to large groups to achieve common learning goals. Instead of learning individually, students share knowledge, discuss ideas, teach each other, organize themselves (often) and solve problems collectively. This enhances self-directed learning, teamwork skills, critical thinking, communication, etc.

- Distinctive features
  - Group-based interaction. Learning via peer discussions and teamwork.
  - Shared responsibility. All members contribute (cooperative).
  - Diverse perspectives. Exchanges to enhance understandings.
  - Teachers as guides.
  - Always used in the frame of other methodologies, such as PBL.
- Learning outcomes
  - Encourages active participation and engagement.
  - Fosters teamwork and leadership abilities.
  - Develops communication and interpersonal skills.
  - Enhances problem-solving and critical thinking.
  - Supports deep or significant learning through discussion and peer learning.
- Examples
  - Team-Based Problem Solving. Analyse cases and propose solutions.
  - Collaborative Projects. Students co-create presentations, reports, or products.
  - Collaborative methods, such as Think-Pair-Share" or "Jigsaw Learning".
- Associated technologies
  - Online Collaboration Tools. Google Docs, Miro, MURAL, etc.
  - LMS. Moodle, Canvas, Microsoft Teams, etc.
  - XR platforms for immersive team-based training (in SBL, etc.).
  - Discussion forums & chat apps. Example: Slack, Discord, etc.
- Challenges, limitations for adoption
  - Unequal participation. Difficult assessment, specially of individual contributions.
  - Time-consuming, reduced learning efficiency.
  - Group conflicts.

Case-Based Learning (CBL) [33]. It is a student-centred methodology where learners analyse real-world cases to apply existing knowledge, develop critical thinking, and improve decision-making skills. Cases are structured (typically written) scenarios that simulate authentic workplace and professional challenges, requiring learners to analyse, evaluate, discuss, and propose solutions.

- Distinctive features
  - Predefined, structured cases.
  - Application of acquired knowledge (already existing).
  - Facilitated discussions. Usually, the teacher guides (not fully inquiry).
  - Decision-making focus. Cases are oriented towards a solution.
  - Cases cand adopt a multidisciplinary approach.
- Learning outcomes
  - Strengthens analytical and decision-making skills.
  - Enhances problem-solving through real-world contexts, use-cases, etc.
  - Encourages critical thinking and evidence-based reasoning.
  - Develops collaboration and communication skills in group discussions.
  - Helps in bridging the gap between theory and practice.
- Examples
  - Medical training. Students analyse a patient case file, diagnose an illness, and recommend treatment.
  - Business & management. Learners examine a struggling company's financial reports and propose strategies for recovery.
  - Engineering. Teams evaluate the better climatization solution to a given building or space, considering structural and environmental factors, users' habits and budget.
- Associated technologies
  - Case-based Learning Platforms.
  - Simulation Software.
  - LMS and collaboration tools.
- Challenges or limitations for adoption
  - Limited scope of the learning outcomes.
  - Instructor-dependent to ensure meaningful discussions, analysis, etc.
  - Case quality matters. Poorly designed cases limit engagement.

Problem-Based Learning (PBL) [33]. In this methodology learners work in groups to solve complex, real-world problems. Instead of being given direct instructions and directions, students must research, analyse, and develop solutions, fostering critical thinking, collaboration, and self-directed learning. The problems may be open-ended, ill-structured and multidisciplinary, not necessarily in the form of tangible realizations as in PjBL.

- Distinctive features
  - Real-world, open-ended problems. Relatively complex problems.
  - Inquiry-based learning. Learners identify what they know, as well as what they lack and need to acquire to solve the problem. Self-directed.
  - Teacher as facilitator. Instructors do not provide direct solutions.
  - Collaborative teamwork.
  - Interdisciplinary approach. Knowledge from multiple fields.
- Learning outcomes
  - Develops critical thinking and problem-solving skills.
  - Enhances self-directed learning and research abilities.
  - Improves teamwork, communication, and collaboration.
  - Strengthens the ability to apply knowledge in real-world contexts.
  - Encourages adaptability and creative thinking.
- Examples
  - Healthcare. Medical students diagnose a simulated patient case but, differently from a structured case in CBL, they need to research symptoms, diseases, or treatments.
  - Environmental Science. Learners tackle pollution issues in a local community and propose sustainable solutions with their rationale.
- Associated technologies
  - Collaborative Tools.
  - Simulations & Case-Based Software.
  - Maker spaces (for prototyping, research, etc.).
- Challenges, limitations for adoption
  - Requires high student engagement.
  - Time-consuming.
  - Difficult to assess learning outcomes. Solutions may differ significantly.

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- Teacher training needed. New roles as facilitators are required.

Flipped Classroom Methodology (FC) [22]. It is an instructional model or an overarching methodology where traditional lecture-based content in school-based training (also in traditional online learning), is learned independently before class, allowing in-class time to focus on more active learning, problem-solving, or hands-on activities. So, instead of using class time for direct forms of instruction, students engage in collaborative work, discussions, practical exercises or work in projects/problems/cases, etc.

- Distinctive features
  - Pre-class learning. Students study instructional materials (videos, readings, tutorials, etc.) before coming to class.
  - Active, student-centred classroom. In-class time is used for clarifications, discussion, problem-solving, and practical application.
  - Teacher as facilitator. Not lectures in classes.
  - Technology-supported learning. Typically, online platforms provide on-demand access to materials.
  - Encourages peer learning. Students collaborate and support each other.
- Learning outcomes
  - Enhances self-directed learning and responsibility.
  - Increases student engagement and participation.
  - Strengthens collaborative problem-solving abilities.
  - Promotes deeper understanding through hands-on practice.
  - Improves critical thinking and application skills.
- Examples
  - Electricity & Electronics. Students watch tutorials on circuit theory at home and spend class time solving more complex problems, building, troubleshooting circuits, etc.
  - Medical training. Trainees study surgical procedures via VR modules before performing hands-on practice in a simulated lab.
  - Business & Management. Students analyse theory and case studies before class, then engage in group decision-making exercises.
- Associated technologies

   - Textbooks and traditional learning materials (notes, exercises, etc.).
   - Maker spaces (for prototyping, research, etc.).
   - Learning Management Systems (LMS).
   - Video Platforms.
   - Collaborative Tools.
   - XR technologies. Advanced simulation.
- Challenges, limitations for adoption
   - Requires strong self-motivation.
   - Technology and access issues. Connectivity.
   - Quite difficult for some subjects, especially some practical skills require in-person demonstrations, timely feedback, high support, etc. (direct instruction).
   - Teacher adaptation. Instructors must redesign lesson plans to fit the flipped model.

Competency Based Learning. This methodology focuses on the acquisition and demonstration of specific competencies or skills. Instead of progressing through a curriculum based on time spent in class, learners advance once they have demonstrated mastery of particular elements of significative (e.g. occupational or academic) knowledge. The emphasis is usually on practical, real-world application of knowledge.

- Distinctive features
   - Mastery before advancement.
   - Learner-paced progression.
   - Clear learning outcome. Specific competencies or skills.
   - Focus on practical skills.
   - Flexible learning paths. Not necessarily based on training (e.g. through work experience, assessments, etc.).
   - Many forms of materialization. In formal and no formal training contexts.
- Learning outcomes
   - Mastery of specific skills or knowledge.
   - Increased self-regulation and autonomy.
   - Improved job readiness or employability.

  - Personalized learning experience.
- Examples
  - In formal VET. Modular qualification programs for different sectors.
  - In no formal VET. Certifications, licenses, etc. official or proprietary.
  - Online Learning Platforms. e.g. Coursera or Udacity.
  - In corporate training. Tailored training systems based on competencies.
  - Competency based learning and microcredentials systems. Learners acquire and demonstrate competencies, while microcredentials provide formal recognition of those competencies in a stackable, verifiable format (in formal and no formal settings).
- Associated technologies
  - Learning Management Systems (LMS).
  - Competency Mapping Tools for management.
  - Digital Badges & Micro-Credentials. eg. Credly.
  - Assessment Tools. For evaluating competencies.
  - Educational technology linked to the type of competences learnt.
- Challenges, limitations for adoption
  - Initial setup complexity. Requires collaboration of many stakeholders.
  - Lack of standardization, specially out of formal public systems.
  - Need for learner motivation, when learners progress at their own pace.

Work-Based Learning (WBL). This can be seen as a very broad learning methodology that combines formal education with several forms/models of direct workplace experiences. It allows learners to develop technical and employability skills through hands-on practice in real work environments.

- Distinctive features
  - Integration of workplace and school-based learning.
  - Experiential, hands-on approach.
  - Interactions and guidance from professionals.
  - Alignment with industry needs.
  - Main assessments through real tasks.
- Types of WBL

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- Apprenticeships. Formal, structured programs where learners work under skilled professionals while receiving education (e.g., electrician apprenticeships).
- Internships. Short-term, supervised work experiences that provide practical exposure to a profession (e.g., engineering or business internships).
- Education in alternation. Alternating periods of study and paid work experience related to a learner's field.
- Job Shadowing. Short-term experience where learners observe professionals in real work settings.
- Industry Projects. Students work on real company projects, solving industry-related problems.
- (Corporate training) On-the-Job Training (OJT). Employees receive hands-on training while performing actual job tasks.

- Learning outcomes
  - Mastery of technical and job-specific skills.
  - Development of problem-solving and decision-making abilities.
  - Increased work readiness and employability.
  - Understanding of workplace culture and professional expectations
  - Examples
  - In formal VET, but also in corporate training and no formal training.
- Associated technologies
  - Educational technology and professional resources.
  - LMS.
  - Management software.
  - E-Portfolios.
- Challenges, limitations for adoption
  - Requires strong industry partnerships.
  - Workplace constraints.
  - Difficult assessment standardization.
  - Learner access issues.

Serious games and gamification (SG). Gamification is not a standalone learning methodology, but rather a strategy or set of techniques used to enhance learning experiences that must happen under other pedagogical approaches. It involves applying game-like elements (such as points, badges, leaderboards, and challenges) to non-game activities and contexts to engage and motivate learners. However, serious games can be considered a learning methodology because they have structured a learning pathway through gameplay, and provide a guided, interactive approach to skill development. They are special types of simulators. Unlike neat simulations, which focus on realism and accuracy, serious games incorporate game mechanics to drive motivation, experimentation, decision-making, etc.

- Distinctive features (serious games).
  - Real-World simulation.
  - Interactive & engaging. Uses challenges, competition, feedback, and goals to keep learners motivated.
  - Decision-based learning.
  - Safe experimentation.
  - Progression & rewards. May use levels, scores, leaderboards, or virtual rewards to keep learners engaged.
- Learning outcomes
  - Decision-making & problem-solving.
  - Soft skills & teamwork. When collaborative.
  - Technical skill development.
  - Increased engagement & motivation.
- Examples
  - Business & management. Marketplace Simulations.
  - Engineering & manufacturing. e.g. "SimSpray" helps train workers in industrial painting techniques.
  - Cybersecurity & IT. e.g. "CyberCIEGE" teaches network security through a strategy-based serious game.
- Associated technologies
  - Software simulation and immersive simulation.
  - AI-driven adaptive learning. Adjusts difficulty based on learner performance.
  - Cloud-based simulation platforms. Provides multi-user collaboration and remote learning.

  - Gamification tools for developers.
- Challenges, limitations for adoption
  - Development costs. Expensive.
  - Balancing fun & learning. Learners may focus on winning rather than learning.
  - Technology barriers. Some serious games require high-performance hard. and soft.
  - Scalability issues for multi-user simulations to handle large numbers of learners.

Concluding, it is important to highlight the relationships among these teaching methodologies, as well as the convenience of "**hybrid approaches**" during the teaching planning process. To illustrate, Collaborative Learning (CL) is often used with other methodologies:

- CL + PBL. Teams solve complex, real-world problems together.
- CL + FC. Pre-class learning is done individually, then discussed in peer groups.
- CL + PjBL – Students co-develop projects, applying shared knowledge.

In each training case, these "hybrid approaches" should be explored as a mean to increase the effectiveness, efficiency and attractiveness of the teaching program.

3.4. Educational technology

3.4.1. Definition and classification

Since the start of formal massive education, training and education programs have been supported on some type of educational technology to materialize methodologies and methods. This technology, as in any other activity sector, is highly valuable under continuous improvement and innovation perspectives. To illustrate, once was the chalk and blackboard, today the interactive smartboard. This illustrates the enduring idea of "Technology-Enhanced Learning", nowadays elevated to the category of a teaching paradigm. Any technology applied to the teaching and learning process is an educational technology. A formalized and up to date definition [34] is: **Educational technology (EdTech) is the study and ethical practice of facilitating learning and improving performance by creating, using, and**

managing appropriate technological processes and resources.

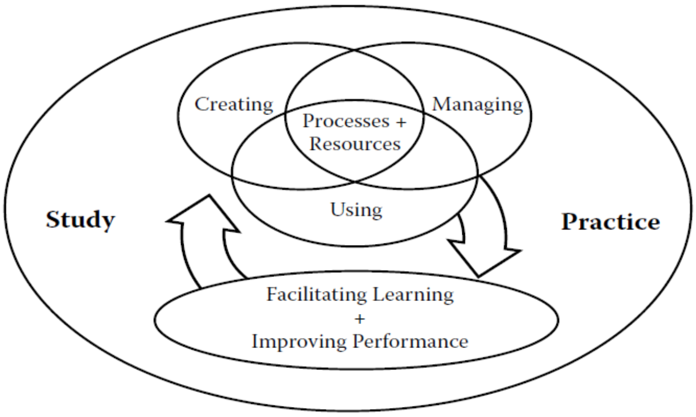

Figure 3. Visual summary of the definition of Educational Technology

Many deep insights are enclosed in this definition:

- **Study**. EdTech is a field of research, like learning, teaching and assessment.
- **Ethical practice**. About the professional conduct of practitioners of EdTech.
- **Facilitating**. Reflects teaching as facilitation rather than control to learn.
- **Learning**. Assume current interpretations from the learning sciences.
- **Improving**. Increased learning effectiveness & efficiency drives EdTech.
- **Performance**. EdTech helps to apply what has been learnt.
- **Creating**. Educational systems, environments, instructional materials, etc.
- **Using**. EdTech for teachers, i.e. used in the implementation of training.
- **Managing**. Increasingly sophisticated EdTech environments need mgmt.
- **Appropriate**. Optimized EdTech and associated processes.
- **Technological**. It means the application of a scientific knowledge.
- **Processes & Resources**. Activities and results of EdTech as an industry.

It worth noting that **educational technology does not teach by itself**. It is effective insofar the teaching method to which gives support it is. Now, there exist many useful criteria to classify EdTech, such as purpose, functionality, or technological foundations. Here, some examples:

Based on mode of delivery:

- Synchronous learning technology. Real-time interaction between teachers and learners (e.g., live virtual classes, webinars, video conferencing, etc.).

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- Asynchronous learning technology. Learning occurs at the learner's pace without real-time interaction (e.g., recorded lectures, online courses, discussion forums).
- Blended learning. The mix of online and face-to-face learning (e.g., flipped classrooms and other hybrid learning models: semi-presential, etc.).

Based on major technology applied:

- XR Technologies. VR, AR and MR for immersive learning experiences.
- Artificial Intelligence (AI) in training and education. Any type of AI-powered tutors, and adaptive learning platforms.
- LMS. Platforms for managing, storing and delivering educational content.
- Simulators.
- Real systems, tools, processes, environments… adapted to training settings.

Based on educational purposes:

- Instructional technology. Tools and methods used to support training (e.g., smartboards, digital textbooks, a technology trainer, etc.).
- Assistive technology. Designed for learners with disabilities (e.g., speech-to-text software, screen readers).
- Assessment and evaluation technology. Automated grading tools, etc.
- Technology for personalized learning. Adaptive technologies.

Based on learning environment:

- Formal and no formal educational technology. Used in structured education settings like schools, universities, training institutions and others.
- Informal educational technology. Self-learning tools such as educational apps, YouTube tutorials, MOOCs (Massive Open Online Courses).

3.4.2. Sample of educational technology used in VET

This is a very large and rapidly evolving topic [35], [36]. Just for guiding about current technologies that are impacting and shaping in some ways generic blended/hybrid VET programs and settings, below there is a list of selected technologies organized by their specific functions, and with some examples for major illustration. Generically, these functions have to do with facilitating teaching, learning and assessing, as well as teaching development and management. Also, VET programs and settings must be broadly understood, meaning that this technology apply to any VET area, to school-based programs, WBL and blended, in formal and no formal training, in self-training and long-life learning, and in other technical and vocational scenarios of young and adult people.

Simulators and other training equipment. *Basic function: provide hands-on, practical training in controlled environments for learning, either in-person or remotely.*

- **Professional tools**: Actual tools and equipment used in professional environments, such as hand tools, machines, software, materials, instruments, and products. *Examples: CAD software, measurement tools, etc.*
- **Machinery Simulators:** Simulate the operation of heavy machinery or industrial equipment for training purposes without the need for the real model. Examples: *Adapted/Scaled/Simulated CNC machines.*
- **Vehicle Simulators:** Designed to replicate the operation of vehicles and motorized tools, providing training for safe operation and situational awareness. *Examples: Forklift/flight/truck/Crane… simulators.*
- **Process Simulators**: Simulate industrial or manufacturing processes for training in specific fields such as production lines. *Examples: manufacturing line simulators, a power plant operation simulator.*
- **Service Industry Simulators**: Replicate environments in the hospitality or service industry in general, helping learners practice customer service and specific operational skills. *Examples: hotel reception simulators.*
- **Technology Trainers:** Tools and systems that allow learners to practice specific technical tasks such as building and testing installations. *Examples: Bench trainers for electrical systems, welding, PLC, pneumatics, etc.*
- **Digital-Based Simulators:** These simulators use digital interfaces to replicate real-world machines, processes, or tasks for educational purposes. *Examples: Simulated electrical machines, virtual lab setups, digital twins as process and systems simulators (not immersive).*
- **Software for Modelling, Analysis, Design, and Testing**: These tools allow learners to model and simulate, study and test designs before real/simulated implementation of conceived models. *Examples: circuit simulators and many other engineering simulation tools (CAD-CAE).*

- **Equipment for Prototyping and Experimentation**: Tools used to create physical prototypes or conduct hands-on experiments. *Examples: 3D printers, laser cutters, CNC routers, electronics prototyping, etc.*
- **Display and Interaction Technologies**: These technologies enhance teaching and learning through visual aids, interactive media, and effective presentations. *Examples: Interactive whiteboards, projectors, digital TVs.*
- **Classrooms, Laboratories, and Workshops**: These spaces are equipped with various educational tools and technologies for practical learning and organized for higher educational aims, or efficiency. *Examples: Science labs, technical workshops, engineering classrooms, language laboratories, etc.*
- **Remote & Virtual Labs**: Platforms that allow learners to access real equipment remotely for training in online or distant learning modalities. *Examples: Cisco Networking Academy (for networking).*
- **Other technologies**: used for administrative tasks, management simulations, logistics simulations, games, etc. *Examples: supply chain simulators and serious games.*

XR-based Simulators and other advanced simulations. *Basic function: create immersive contexts for hands-on skill development and scenario-based learning using XR, meaning: Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR).*

- **VR Simulations**: Fully immersive environments that replicate real-world tasks or environments, allowing learners to engage in hands-on skill development without physical risks. *Examples: EON Reality, Labster (for science and lab simulations), Simulated welding or machinery operation, Surgical training simulators, etc.*
- **AR simulators for maintenance & repair**: AR overlays digital information onto the real world, guiding technicians and workers through maintenance and repair tasks in real-time. It allows for step-by-step instructions and interactive visualizations of equipment and systems, improving efficiency and reducing errors. *Examples: PTC Vuforia (for equipment servicing and interactive maintenance), AR instructions for machinery, AR-enhanced repair guidance.*

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- **MR applications for industrial training**: It blends the physical and digital worlds, enabling users to interact with both real and virtual objects simultaneously. *Examples: zSpace (for interactive training in fields like engineering, CAD, and anatomy), Microsoft HoloLens (for training in electrical, mechanical, and automation systems).*
- **Immersive Digital Twins**. Integration of real-time data and immersive visualization and interaction. This provides a much richer, more interactive experience for users. *Examples: Siemens' MindSphere. Schneider Electric's twin technology in power grids and smart cities.*

Learning Management Systems (LMS) and Digital Learning Platforms. *Basic function: Organizing and delivering courses efficiently, with flexibility and personalization features.*

- **LMS:** Facilitate the creation, delivery, management, and tracking of online learning experiences. They provide teachers/instructors/coordinators with tools to design courses, upload materials, assess learners, and monitor progress, while learners can access content, submit assignments, and engage in discussions. Many LMSs include interactive features, such as gamification, AI-driven analytics, mobile accessibility, and third-party integrations. *Examples: Moodle, Blackboard, Canvas, etc.*
- **Classroom Management Tools:** These are simplified platforms with LMS-like features, such as integrated communication, assignment tracking, and real-time feedback. However, they often lack built-in analytics, SCORM support, and advanced course customization, among other things. *Examples: Google Classroom, Microsoft Teams for Education.*
- **MOOC Platforms:** These platforms support the delivery of courses, specializations, certificates, and degree programs from universities, industries, and institutions worldwide. They provide massive open online courses (MOOCs) in various subjects, including technology, vocational training, and professional development. Some leverage AI-driven personalization for learning recommendations and adaptive pathways. *Examples: Coursera, edX, LinkedIn Learning, etc.*

Resources for Work-Based Learning (WBL) Management & Industry

Integration. *Basic function: Facilitating employer-training provider collaboration and tracking of apprenticeships and other models of WBL.*

- **Real Systems & Industry Resources**: Providing access to trade tools, real equipment, and industry-relevant settings to enhance hands-on learning.
- **Industry-Driven Training & Real-World Simulations**: Platforms offering simulations or virtual environments to replicate real-world industry scenarios, allowing learners to apply skills in a risk-free setting. Can be accessed from the work settings. *Examples: Siemens Mechatronics Systems Certification Program.*
- **Communication platforms**: Tools that enable real-time communication and collaboration between all parties involved in the WBL program. *Examples: Slack, Microsoft Teams, Zoom.*
- **Project & Apprenticeship Management Tools**: Platforms for organizing and tracking tasks, milestones, and projects in industry-based learning. *Examples: Trello, Asana (customized for WBL programs).*
- **LMS for WBL:** Systems designed specifically for managing work-based learning experiences, tracking progress, and integrating assessments and certifications. *Examples: eFront, WorkReady, XAPI-powered LMS.*
- **Progress & Feedback Tools**: Platforms for gathering feedback from employers, trainers, and peers, allowing continuous assessment of learner progress. *Examples: 360-Degree Feedback tool.*
- **Skills & Competencies Tracking Systems**: Systems for tracking learner skills, competencies, and certifications throughout their WBL experience. *Examples: Skillsoft, Vervoe, and Learning Record Stores (LRS).*
- **Performance Analytics Dashboards**: Visual dashboards that consolidate data on learner performance, employer involvement, and program success, enabling informed decision-making. *Examples: Power BI, Tableau.*
- **Employer Engagement & Matching Platforms**: Platforms to connect learners with suitable employers, track employer involvement, and ensure alignment with industry needs. *Examples: Find an Apprenticeship (UK).*
- **Compliance & Certification Tools:** Tools for ensuring compliance with industry standards and regulatory requirements, along with issuing certifications to successful learners. *Examples: CertifyMe, Accredible.*

- **Data Privacy & Security Tools**: Tools to protect sensitive learner data, ensuring compliance with data privacy regulations and maintaining confidentiality throughout the WBL process. Examples: GDPR-compliant platforms.

Learning materials, including digital texts, e-books & online resources. *Basic function: traditional learning and teaching materials, digital access to learning materials and digital resources enhanced with interactive features.*

- **Learning materials oriented to students**. *Examples: textbooks, exercise and practice manuals, instructional guides, etc. Printed, digital, multimedia, interactive…*
- **Materials oriented to teachers**. *Examples: Slides for lecturing, instructional guides, etc.*
- **Interactive e-books for technical courses**. *Examples: VitalSource, Pearson eText.*
- **Open-access digital library of educational resources**.
- **Free educational resources and course materials**. *Example: OpenStax.*

Collaboration Tools for Teachers & Students. *Basic Function: Facilitating teamwork, communication, and resource sharing to enhance collaborative learning and professional development.*

- **Platforms for sharing multimedia resources and collaborative feedback**. Tools that allow educators and learners to upload, share, and collaborate on multimedia content like documents, images, and videos. These platforms also enable real-time feedback. *Examples: Padlet, OneDrive.*
- **Project-based learning tools for managing assignments and group work**. Tools that help organize and manage group assignments, track progress, and ensure accountability in team-based tasks. *Examples: Trello, Asana for Education.*
- **Social learning platforms that facilitate collaboration**. Platforms designed to encourage discussion, idea sharing, and peer collaboration. These tools foster communication and can simulate the collaboration found in professional environments. *Examples: Edmodo, Flipgrid.*

Smart Classroom Management & Tools. *Basic function: Streamlining classroom activities, engagement, and student tracking.*

- **Interactive whiteboards.** *Examples: Promethean, Smart Board.*
- **Collaborative brainstorming platforms**. Digital tools that facilitate group discussions, idea generation, and project collaboration in an online or hybrid classrooms. *Examples: Jamboard, Miro for Education.*
- **Monitor student screens**, manage access to resources, track progress, etc. *Examples: NetSupport School.*
- **Gamified classroom mgmt.** for engagement and behaviour tracking. *Examples: Classcraft.*
- **Digital attendance, behavior tracking** and more. *Examples: Klassly, iDoceo.*

Multimedia Content Creation & Delivery Tools. *Basic function: Creating and delivering engaging multimedia content.*

- **Platforms for sharing instructional videos**. *Examples: Vimeo, YouTube Education, Panopto.*
- **Interactive video, animations, and quizzes.** *Examples: Camtasia, Adobe Captivate, Articulate Storyline.*
- **Animated videos for concept explanations**. *Examples: Powtoon, Animaker.*
- **Visual design tool for creating course materials**. *Examples: Canva for Education.*
- **Interactive video lessons with integrated assessments**. *Examples: TED-Ed.*

AI-Powered Personalized Learning & Pedagogical Agents. *Basic function: Personalizing learning experiences through adaptive systems, including AI tutors and learning analytics.*

- **Adaptive Learning Platforms**: These platforms use adaptive learning design to tailor content based on individual learner needs. Most modern systems are AI-driven and adjust content dynamically based on real-time learner responses. Teachers can create interactive, personalized learning experiences. *Examples: Smart Sparrow (now part of Pearson), Knewton, Century Tech.*

- **Virtual Tutors:** These systems provide personalized, interactive tutoring and feedback using technologies like Natural Language Processing (NLP) and machine learning. They adapt to learners' needs in real time. *Examples: Watson Tutor, ChatGPT for Education.*
- **AI-Powered Tutoring and Problem-Solving**: These platforms provide conversational AI tutoring and assessment solutions to encourage open-ended discussions and help learners develop critical thinking and problem-solving skills. *Examples: Cognii, ALEKS (for Math & Science).*
- **Learning Analytics Dashboards**: These dashboards track learner progress and can serve as early warning systems for identifying struggling students. They provide valuable insights for personalized learning frameworks. Examples: XAPI-powered dashboards in Moodle with Learning Record Store (LRS) integration.
- **Adaptive Immersive Learning in Technical Fields**: These solutions offer personalized, interactive mentoring in virtual environments, particularly useful for technical training. Examples: EON Reality AI Mentor in VR.

Assessment Tools & Personalized Feedback. *Basic function: Providing personalized assessments and feedback to monitor learning progression, improve skills, and facilitate continuous development.*

- **AI-assisted grading of assignments and tests.** AI-driven platforms that automatically grade assignments, tests, or exams, streamlining the grading process and providing faster feedback. Thet can support the assessment of written work, multiple-choice questions, and practical assessments. *Examples: Gradescope, Turnitin GradeMark.*
- **Interactive quizzes with multimedia**. These tools can be used to assess both theoretical knowledge and practical skills, and to gamify. *Examples: Quizlet, Kahoot!, Quizizz.*
- **Peer feedback, plagiarism detection**, grammar checks tools. *Examples: Turnitin with Feedback Studio, Peergrade.*

- **AI-powered grading tools for multimedia assignments**. AI tools designed to automatically grade multimedia assignments (e.g., videos, presentations, simulations) and provide instant feedback. Useful where submission of practical, performance-based assignments is required. *Examples: SpeedGrader, Cognii.*

Remote Proctoring and Exam Security. *Basic function: Ensuring secure online assessments and preventing cheating during assessments.*

- **Remote proctoring with AI monitoring and live teacher intervention**. *Examples: ProctorU, Examity.*
- **Prevents cheating by locking down browsers during online exams**. *Examples: Respondus LockDown Browser.*

Digital Credentialing and Badging. *Basic function: Digital certifications and badges for tracking skills and qualifications.*

- **Digital badges and credentials for skills and certifications**. *Examples: Credly, Open Badges.*
- **Secure, verifiable digital credentials for qualifications**. *Examples: Blockchain for Credentialing.*

AI-Based Classroom and Learning Analytics. *Basic function: Analysing student behaviour and learning patterns to provide personalized insights.*

- **Learning analytics platforms to track and predict student outcomes**. *Examples: BrightBytes, PowerSchool Analytics.*
- **Personalized learning analytics and interventions**. *Examples: Edmentum*

3.5. Regional and national experiences in VET innovation

3.5.1. Basque Country region and Spain

ETHAZI METHODOLOGY

- **Identification and origins**
  - *Name*: ETHAZI - Etekin Handiko Zikloak (High Performance Cycles).
  - *Short description*: a methodology of collaborative learning based on challenges.
  - *Application context*: IVET. Public and Private subsidized networks of VET Centres.
  - *Scope*: Regional (Basque Country, Spain)
  - *Promotes*: Education Department of the Basque Government. VET work area. In Collaboration with TKNIKA-Centre for Applied Research and Innovation in VET and the VET network.
  - *Starting year*: 2013-2014 (pilot phase in 5 VET centres with 100 students, 25 teachers and 5 VET Programs of different occupational families).
  - *Ending year/status*: still active.
  - *Reference(s):*

https://tknika.eus/cont/proyectos/ethazi/#

- **Objectives and characteristics**

ETHAZI's main goal is to improve students' skills through a collaborative learning methodology based on challenges, promoting the acquisition of technical and soft competencies. It is in fact an innovative teaching model based on the following principles:

- Interdisciplinary Projects: Learning is organized around projects that integrate multiple subjects (i.e. Content modules of the VET Program), reflecting real industry challenges.
- Collaborative Learning: Students work in teams to solve real-world problems, fostering teamwork and communication skills.
- Competency-Based Assessment: Evaluation focuses on students' ability to apply knowledge and skills in practical situations.

- Role of Teachers as Facilitators: Instructors guide students through the learning process, encouraging self-directed learning and critical thinking.
- Industry collaboration: Diverse forms of participation are required from industry to keep learning challenges close to real work, and, more recently, to give support to mandatory WBL modalities.

The ETHAZI model introduces PBL, using workplace situations as challenges for learners to solve applying specific vocational/technical and soft skills. To do this, students are organized into teams and work together as they would do in the workplace. This process has four main characteristics:

- (1) It is modular, with the design of challenges simulating as closely as possible the real work/life situations in the school setting. And progressively integrative of the diverse aspects of the occupational role and its constituting competencies.
- (2) It has self-managed teaching teams where teachers are encouraged to cooperate and, if needed, adjust their schedules according to their students' needs. Each teacher is fully available to students during their working hours.
- (3) It includes formative and summative assessments to guide the evolution of competencies acquisition. The assessment is integrated as a key element in the students' own learning process, and frequent feedback is provided about learning progression, for orientation and self-reflection.
- (4) Learning spaces (classrooms, laboratories, workshops…) are adapted as flexible, open, interconnected and equipped for communication (ICT) spaces, that foster the intended collaborative and self-directed work.

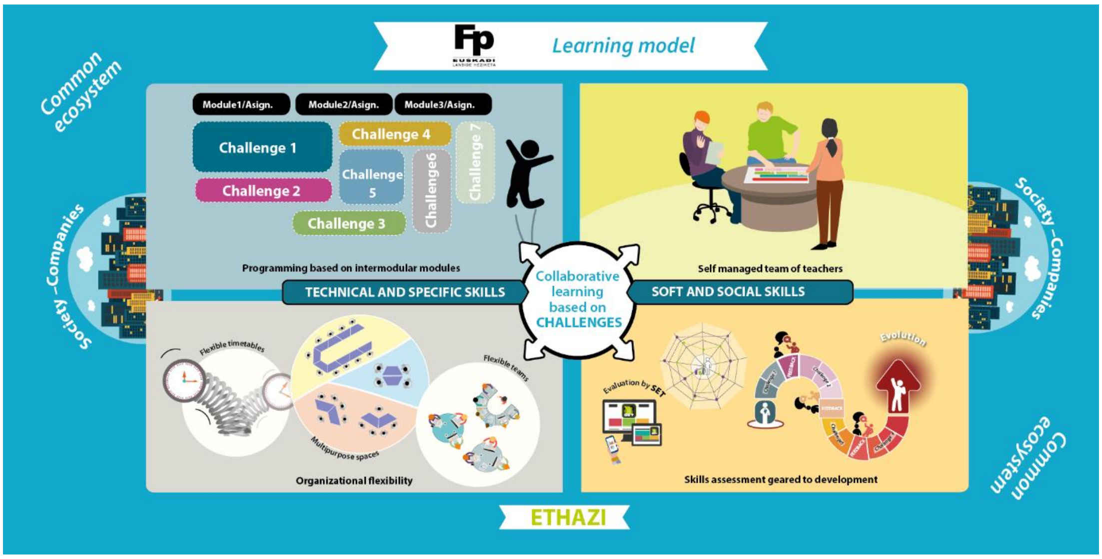

Figure 4. A view of the ETHAZI model

- **Results, impacts and expansion**

Recently, ETHAZI turned 10 years old. Over this decade, the model has expanded significantly. During the 2023-2024 academic year, 25,421 students from 83 training centres, with the involvement of over 2,000 teachers, participated in this learning model. In total, nearly 80,000 students have been trained under the ETHAZI methodology.

ETHAZI is under continuous improvement of the methodology and the specific methods and management tools used, along with other resources. For example, ETHAZI is in the process of integrating the newest technologies in the network to make the learning process more active and adaptive. Dissemination plays a core role for expansion. This is accomplished through frequent teacher training and promotion campaigns for Centres (showing good practices), as well as for learners and the wider context (employers) to show the attractiveness and effectiveness of the teaching approach. Also, ETHAZI has been disseminated at national and international level through the VET innovation networks operating in the public Basque VET system.

Finally, a major challenge is the adaptation of ETHAZI to the more recent DUAL modalities of IVET programs, which are mandatory in the general VET system (Spain).

- **Conclusion**

It can be said that ETHAZI has transformed significantly the Basque Country's VET, adapting the training to the real needs of the labor market, and preparing students to face professional challenges with a more comprehensive and practical education.

CONTRATO DE FORMACION EN ALTERNANCIA CON EL EMPLEO

- **Identification and origins**
  - *Name*: Training Contract for Training in Alternation.
  - *Short description*: a training pathway or model in alternation with a paid job in a DUAL-like model operating in the CVET system.
  - *Application context*: CVET. All qualification levels, complete or partial.
  - *Scope:* National (Spain).
  - *Promoted/Realized by*: Spanish government in collaboration with the State Public Employment Service (SEPE) and Training System for Employment (FPE).
  - *Starting year*: regulatory framework updated in 2022, with antecedents in previous dual training modalities for VET and University.
  - *Ending year/status*: current.
  - *Reference(s):*

https://tinyurl.com/558t5bhu

- **Objectives and characteristics**

High levels of unemployment in young people are a historic issue in Spain. To deal with this problem, there long exist regulated so-called Training Contracts. They are in general characterized by an academic or vocational training that is accomplished in alternation with a paid professional activity. On the side of employers, these contracts are incentivized in several forms, and have other appeals, such as in staff selection and onboarding. Over the years successive reforms have sought to make Training Contracts in general even more attractive and effective options, notably by strengthening the educational facet in line with reforms in the IVET and University systems.

In particular, the Training Contract in Alternation has become an educational model like the DUAL models of IVET programs. Meaning this, the three main parts involved, Employers, Training providers and Learners, are nowadays more deeply related for the sake of a collaborative and quality education. In accordance with the provisions in the Workers' Statute, **the specific purpose of the Training Contract in Alternation will be to make the paid labor activity compatible with the corresponding training processes,** in the field of vocational training, university studies or the Catalog of training specialties of the National System of Employment.

Some salient characteristics of this Training Contract in Alternation are:

Participants, and conditions for opting to this modality

- Young unemployed people between 18 and 30 years old for lower qualifications.
- Unemployed with not age limit, for higher VET qualifications and HE.
- Learners do not have any official titles related to the job vacancies.
- Administrative conditions that must be met by employers.

Training

- All formal qualifications and certificates operating in the Training System for Employment (FPE); also, IVET programs and HE programs. Total or partial.
- Accessible online or presential, depending on the training provider.
- Training providers: accredited training centres for CVET, e.g. industry associations, training companies, CVET centres, NGO, private education centres, etc.

The Contract

- Minimum duration of 3 months and a maximum of 2 years.
- Full-time or part-time according to the employers' needs.
- The working day is divided between actual work and formal training.
- Maximums of first year: 65% worktime and 35% training time.
- Maximums of second year: 85% worktime and 15% training time.
- Contract + Annexes. Identified employer, employee, training centre and tutors.

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- Annexes: Individual Training Plan. Collaboration Agreements.
- The training must be related to the job.
- The learners are paid proportionally by the worktime done.

The learner

- wants to combine their training with a job, and applies for available job offers,
- engages with their training and respects agreed working & studying hours,
- makes the assigned work and follow the training program,
- has the support and feedback from both the centre and workplace tutors.

The Employer,

- includes companies, public companies and institutions, and others,
- wants to hire people under this modality, and make job offers,
- selects and hires people for the job vacancies offered,
- appoints a workplace tutor,
- coordinates with the centre and signs collaboration agreements,
- assigns work to the learners that must be directly related to the training activities that justify the employment contract,
- gives support and assesses learners in the workplace,
- respects schedules and calendars for study and work (exams, etc.).
- obtains tax reductions, keeping accountable to competent Administration.
- ending the contract, decides if the learner should be permanently hired.

The training or education provider,

- promotes and informs learners and employers about this option.
- prepares official collaboration agreements with the employer and helps with individual training plans,
- manages their own training catalogue or offerings, contacts with employers, networking, etc.,
- gives advice about and facilitate administrative and legal formalities.
- appoints centre tutors, and coordinates with the workplace tutors.
- delivers the training, gives support and assesses learners.
- processes corresponding official certificates.

 - keeps accountable to the training authorities during the contract.

- **Results, impacts and expansion**

  This training in alternation with the job has gained relevance in these last years. In 2024, 54,987 Training Contracts in Alternation were formalized, a figure that represents an increase for the third year in a row. Once again, companies are trusting this type of contract to generate employability in young people, specifically 28,507 women and 26,480 men. Companies from a diversity of sectors have incorporated young talent at reduced staff selection costs, while actively contributing to their vocational education by collaborating more closely with the academic world in effective DUAL-like frameworks.

- **Conclusion**

  The Training Contract for Training in Alternation has been consolidated as a key pathway within the CVET system in Spain.

3.5.2. Creta region and Greece

<u>TRAINER TRAINING IN VET</u>

- **Identification and origins**
  - *Name*: Trainer Training in Vocational Education and Training.
  - *Short description*: a methodology of collaborative learning based on challenges applied to VET teachers and instructors.
  - *Application context*: VET Teachers & Instructors Training.
  - *Scope*: National (Greece)
  - *Promoted/Realized by*: National and Kapodistrian University of Athens (EKPA).
  - *Starting year:* 2025
  - *Ending year/status:* still active.
  - *Reference(s):*

https://elearningekpa.gr/courses/ekpaideush-ekpaideutwn-sthn-epaggelmatikh-ekpaideush-kai-katartish#course-introduction

- **Objectives and characteristics.**

The purpose of the training program is to acquire knowledge and develop skills that are essential for an effective trainer of trainers operating in the field of vocational education and training.

Specifically, the objectives of this program are:

1. To develop a comprehensive understanding of the institutional framework of vocational education and training both in our country and in other countries.
2. To outline the European framework of professional qualifications and the certification of vocational training.
3. To highlight the profile and qualifications of a trainer of trainers in vocational education and training.
4. To connect vocational education and training with the labor market.
5. To develop skills related to communication and problem-solving within the learning group.
6. To reform and improve methodological approaches and practices applied within the framework of vocational education and training.
7. The provision of expertise for the design and evaluation of a vocational education and training program.
8. The stimulation of critical thinking and dialogue to address prejudices and stereotypes related to vocational education and training.
9. The description of experiential activities that promote the reconsideration of thought processes and applied practices in vocational education and training.
10. The design of microteaching sessions aimed at reflection and feedback.

The units are laid out as follows:

Teaching Unit (TU) 1: Lifelong Learning – Labor Market and Vocational Education and Training in Our Country and Other European Countries

TU 2: Basic Learning Theories and Trainer Education in VET.

TU 3: The Qualifications of a Trainer of Trainers in VET.

TU 4: Communication Skills and Emotional Relationships in the Learning Group: Verbal and Non-Verbal Communication Between Trainer and Trainees

TU 5: Cultural Diversity and Managing a Multicultural Group

TU 6: Vulnerable Social Groups and Trainer Handling Strategies

TU 7: Development of an Educational Program in VET: Curriculum – Manual – Teaching Material

TU 8: Lesson Planning in VET: Modern Methodological Approaches

TU 9: Strategy and Educational Techniques in VET I

TU 10: Educational Techniques in Vocational Education and Training II

TU 11: Art and Visual Representation in VET

TU 12: Empathetic and Experiential Activities: Demonstrative Application

TU 13: Evaluation in VET.

TU 14: Microteaching and Micro-Lessons: Practical Training

TU 15: Design and Implementation of Microteaching in VET.

- **Results/Impacts/Expansion/Challenges.**

Teaching in the distance learning professional training programs of the Center for Training and Lifelong Learning at the National and Kapodistrian University of Athens (EKPA) is conducted online. This offers the trainee "autonomy," meaning the ability to study without restrictive factors such as the obligation of physical presence in a specific place and time.

The educational material of the program is made available gradually, per instructional unit, through specially designed online classrooms. During the progression of each thematic unit, relevant announcements necessary for the smooth conduct of the educational process are posted via a designated link.

After completing the study of each instructional unit, the trainee is required to electronically submit the corresponding evaluation test. These tests may include matching correct answers, multiple-choice questions, true/false statements, or uploads where the trainee must formulate and attach their response. The thematic unit may also be accompanied by a final assignment, which becomes available upon the completion of the unit (if required by its nature) and covers the entire syllabus.

Additionally, full educational support is provided, as trainees can contact their designated instructor electronically (for the duration of the course) through the platform's built-in communication system. This ensures the immediate resolution of questions related to the thematic units, evaluation exercises, or the final assignment.

- **Conclusion**

The **Trainer Training in Vocational Education and Training** program equips educators with essential knowledge, skills, and methodologies for effective instruction. It covers key areas such as learning theories, communication techniques, multicultural group management, and instructional design. Emphasizing both theoretical and practical aspects, it fosters experiential learning, empathy, and innovative teaching strategies. The program also highlights the connection between vocational education and the labor market, ensuring relevance and applicability. Through microteaching and evaluation, trainers refine their abilities to design and implement impactful lessons. Ultimately, this comprehensive training enhances professional competencies, promoting high-quality education and lifelong learning opportunities.

3.5.3. Italian regions and Italy

<u>TECHNOLOGY ENHANCED LEARNING FOR ELECTRICIANS</u>

- **Identification and origins**
  - *Name:* Several methodologies and associated technology.
  - *Short description:* Continuous changes in technology and labor market needs require constant updating of teaching methodologies in VET pathways. The electrical sector is probably the area most involved in this evolution/revolution because of the now pressing need to produce energy cleanly and manage its consumption in buildings using dedicated energy-saving applications. It therefore becomes crucial to identify existing best practices and to analyse digital methodologies that can be adopted by institutions and VET systems to train future electricians in a more efficient and engaging way. After the three-year course, the path to becoming a **Technician** is characterised by the further **strengthening of** technical and professional skills and those related to mathematics/science and technology, as well as increasing the **levels of responsibility and autonomy in carrying out activities**.

ELECTRICAL TECHNICIAN

The one-year course for the **Diploma of electrical technician (EQF4)** allows the student to work independently on the realisation, functioning and programming of electrical systems, participating in the identification of resources, the design and dimensioning of components and systems, and collaborating in the testing, start-up and commissioning phases of the system. They have the skills necessary for the construction and maintenance of electrical systems, the integration of building automation systems and the design of small-scale civil and industrial systems.

DIGITAL MODELLING AND MANUFACTURING TECHNICIAN

The one-year course for the **Diploma of digital modelling and manufacturing technician (EQF4)**, following on from the Qualification, allows the student to work independently in the creation of prototypes made with additive and/or subtractive machines or electronic prototypes for devices and sensors, participating in the identification of resources, in the operational organisation and in the monitoring of the machines. They have functional skills for project development, for the processing and preparation of technologies and materials, for managing customer relations in the preparation of documentation of conformity/functionality and costs and product presentation.

INDUSTRIAL AUTOMATION TECHNICIAN

The one-year course for the **Diploma of industrial automation technician (EQF4)**, allows the student to work independently in the industrial automation process, participating in the design and dimensioning of components and systems, in the testing, start-up and commissioning phases of the mechatronic system, in the identification of solutions for continuous improvement, in the procedures for monitoring and verifying the correctness and compliance with design and safety standards of the procedures adopted. The graduate has the necessary skills for the design and dimensioning of the automated system and/or plant, for the development of the command and control software, for the installation of the system and/or the relative mechanical, electrical, pneumatic and hydraulic components, for the calibration and regulation of the individual elements and of the automated system as a whole.

SCHOOL-COMPANY RELATIONSHIP

- *Short description:* During the fourth year for the Professional Diploma, School and Company co-design the training, so that technical-professional skills are acquired and perfected in both contexts. During the 4th year, the experience in the company can also be carried out by activating the apprenticeship contract at the 1st level.
- *Application context*: VET.
- *Scope*: Regions of Piedmont, Lombardy, Veneto and Friuli Venezia Giulia.
- *Promoted/Realized by:* several stakeholders (Local authority) and partnerships (Festo/Siemens) + companies.
- *Starting year:* every year
- *Ending year/status*: still active.

- Reference(s). Regional repertoire of professional profiles:

https://rrsp.cliclavoroveneto.it/

- **Objectives and characteristics.**

DIGITAL TEACHING METHODOLOGIES

Digital technologies provide excellent opportunity to enhance learners' learning in the electrical industry using realistic simulations and interactive tools that foster hands-on, direct experience. Such methodologies include:

- **E-learning and online platforms**. They enable students to access learning materials, interactive courses and distance learning modules. Best practices include:
  - MOOCs (Massive Open Online Courses): open online courses that provide theoretical and practical knowledge
  - Cloud (One Drive): system for sharing lessons and exercises between trainers and learners
  - Brilliant: interactive platform focused on STEM subjects
- **Virtual Reality (VR) and Augmented Reality (AR).** Digital simulations ensure that it is possible to practice in realistic scenarios without the risks

associated with installing and operating electrical systems, while at the same time saving on consumables.

- Simulation software for electrical circuits (e.g., Tinkercad, Multisim): allow students to design and test circuits within virtual environments
- VR viewers and AR applications: allow exploration of electrical systems and devices in immersive environments

- **Gamification, project-based learning and challenge-based learning**. The playful elements form the core around which students' motivation and subsequent acquisition of practical skills gravitate.
  - Kahoot: online test and quiz creation platform where learning comes through play
  - Project-based learning: students work on concrete projects addressed to the implementation of home automation electrical systems for energy saving
  - Application of WebQuests as challenge-based learning process through the use of several AI platforms: Chat gpt, Gemini, STORM AI, Study Fetch, This or This AI, Gamma

EXISTING PRACTICES FOR LEARNING PROCEDURES AND METHODS IN CLEAN POWER GENERATION AND ENERGY-SAVING APPLICATIONS FOR THE BUILDING SECTOR

Teaching in the electrical sector integrates the concepts of sustainability and renewable energy, with a focus on solar and wind power as they are the most widespread and accessible sources. Best practices include:

- Study and application of renewable energy systems: the study of photovoltaic systems includes the analysis of solar cells, their configuration, integration of the system with the power grid, and storage through energy storage batteries. For wind energy, the aerodynamic characteristics of turbines, the efficiency of energy conversion, and the optimal conditions for their installation are examined
- Energy management systems for smart buildings (smart buildings): the integration of smart technologies in modern buildings allows for optimized control of energy consumption, reducing waste and improving living comfort.

Facility management includes the use of smart sensors, automation, and the development of algorithms that regulate lighting, heating, ventilation, and air conditioning rooms based on prevailing conditions. The use of building-integrated renewable sources, and the possibility of interconnection with smart grids, enables high energy efficiency

- Energy efficiency using thermal insulation materials: this area involves the analysis of innovative high-performance materials, such as aerogel insulation panels, selective low-emissivity glass, and reflective coatings. The use of advanced construction techniques that improve the thermal inertia of buildings, limiting the need for artificial heating and cooling, is also explored.

3.5.4. Germany

XR-BASED TRAINING FOR ELECTRICIANS

- **Identification and origins**
  - *Name*: Not provided.
  - *Short description*: Siemens and Bilt have partnered to create an immersive extended reality (XR) electrical training program for the Apple Vision Pro headset.
  - *Application context*: IVET & CVET in electrical work.
  - *Scope*: Potentially national or international, depending on adoption.
  - *Promoted/Realized by:* Siemens and Bilt.
  - *Starting year*: 2023 (announced at Apple's Worldwide Developers Conference).
  - *Ending year/status*: Ongoing.
  - Reference(s):

https://press.siemens.com/global/en/pressrelease/siemens-and-bilt-launch-extended-reality-electrical-training-apple-vision-pro

- **Objectives and characteristics.**
  - The program aims to provide a safe and effective way for electrical trainees to learn and practice essential skills using the immersive capabilities of the Apple Vision Pro headset.
  - The XR environment simulates real-world scenarios, allowing trainees to interact with virtual electrical components and systems.

- The training focuses on practical skills, such as wiring a light switch or troubleshooting a circuit, with interactive guidance and feedback.
- The program leverages Vision Pro's eye and hand tracking for intuitive interaction within the virtual environment.

Figure 5. A man wearing an Apple Vision Pro next to a Siemens P5 power panel. He is looking at a digital overlay of BILT immersive instructions including a 3D rendering of the panel and a text window.

- **Results/Impacts/Expansion/Challenges.**
  - It is too early to measure the long-term impacts and results of this program.
  - Potential impacts include improved safety, increased efficiency in training, and enhanced skill development for electrical trainees.
  - Expansion will likely depend on the adoption of the Apple Vision Pro headset and the program's effectiveness in training.
  - Challenges may include the cost of the technology, the development of relevant training modules, and ensuring accessibility for all trainees
- **Conclusion.**

The Siemens and Bilt XR electrical training program for Apple Vision Pro represents an innovative approach to vocational training. By leveraging immersive technology, the program has the potential to transform how electrical trainees acquire and practice essential skills. The program's success will depend on its ability to address challenges and demonstrate tangible benefits for trainees and the electrical industry.

4. Analysis and recommendations.

This section provides a general recommendation for innovative teaching in the provision of education and training for the Smart Electricity for Buildings (SEB) sector. This training has been conceived and developed within the SEBCoVE project.

Basically, the innovative teaching in the SEBCoVE project, (1) is focused on a **methodological transformation** that (2) happens within **a certain educational model** (classifiable as IVET or CVET).

This innovation is expected to generate evidence of good practice in technical and vocational education “of excellence” (according to CoVEs Initiative) for the SEB sector, which may be promoted, adopted and generalized. The section starts with a brief general analysis of this innovative teaching, then, focused on the pedagogical approach, suggest some operating criteria for delimiting it based on methodologies and educational technology. Finally, it provides a list with recommended methodologies for this methodological transformation.

4.1. General analysis

The analysis and decision-making process regarding the pedagogical approach for the SEBCoVE’s VET is informed by the following information:

- The SEBCoVE’s project objectives framed within the European CoVE Initiative and its expected impacts (i.e., the Context of this research). Especially, the goals related with education and training of excellence.
- The Research and Benchmarking findings, including:
  - The European VET landscape and its trends, particularly regarding innovation.
  - Contemporary teaching and learning paradigms, especially in technical and vocational training, addressing both young and adult learners.
  - Evidence-based teaching methodologies, alongside proven and emerging educational technologies.

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- Best practices in VET innovation, especially those related to methodological transformation applied to the SEB sector, or in other close ones.

Essentially, the SEBCoVE's VET model must ensure that learners (including students, workers, and the unemployed) will be optimally equipped with technical, vocational, and employability competencies required to meet the current and future demands of the SEB sector, as they have been identified with the collaboration of industry. Remarkably, this goal can be achieved with the "innovative" traits provided by the methodological stance, and coherent methodologies, adopted along with other necessary features (e.g. quality management of the whole teaching process). When applied to methodology, "innovative" means ways of enhancing the learning experience in particular contexts making this process more effective, efficient and/or engaging.

The following conditions will shape this innovative teaching in general. So, to ensure the innovation is effective, it should consider:

1. Alignment with industry. The training curricula, the programs offered and the promoted teaching in the SEBCoVE's VET will be oriented towards sector-specific competency requirements and occupational roles, to reduce current and future competency gaps caused by technological trends, and other factors.
2. Training service. The teaching approach, including principles, methodologies, methods and resources, will be suited to the education or training service offered, including purposes, certificates, pathways, courses and delivery modes. At the same time, innovative features will be highlighted.
3. Alignment with proven methodologies. The pedagogical approach, including methodologies, method and educational technology, will be consistent with modern learning and teaching paradigms, particularly those applied in adult learning, VET and HE, and will consider the pedagogical recommendations for VET from European authorities.
4. Capability building. Trained teachers and instructors, resources, documented teaching processes and a quality management model will be required to support the innovative service.

5. Empirically tested. The teaching conceived (as a service), with its innovative features, will be developed, implemented, piloted and validated in real training/education settings provided by the regional CoVEs constituted and developed within the project.
6. Scalable and **transferable**. Finally, the training with its components will be documented and configured as a comprehensive process with details about flexibilities and conditions for institutionalization. This is to say, to be potentially adopted within regional and national VET systems, and in other European VET systems.

4.2. Criteria for adoption of an innovative methodology

In this point the focus is put on the methodological stance of the SEBCoVE's VET. To ensure relevance, effectiveness, and sustainability (long-term viability and effectiveness of the methodological change) the following criteria have been identified that can guide the selection of innovative teaching methodologies:

C1. Alignment with SEB sector competencies and occupational roles.

- Learners will develop expertise in competency areas related with the energy management in (smart) buildings, including, **understandings** of building automation, IoT integration, energy management, integration of RES and ESS, smart grids, and cybersecurity areas, as well as design, development, management and maintenance **skills** applied to solutions in each area, along with **attitudinal behaviours** and other relevant occupational knowledge. In essence, the aggregation of these competencies developed at different levels will result in certifications of important roles for the labour market. Coherently, **the methodological approach should be practical, competency-based** to promote this complex knowledge to the minimum standards required.
- To better ensure that training is aligned with real-world tasks and applications, **close collaboration with industry partners will be kept reaching several forms of active involvement** in design, development or implementation. This involvement can represent an innovative trait by itself.

C2. Holistic learner-centred teaching

- Occupational roles and competencies will be translated into a training offer that in general (SEBCoVE's VET model) is levelled, certifiable, cumulable, flexible, adaptable, and work-based. **The teaching approach and the supporting technology will suit these features.**
- A holistic learner-centred teaching, promoted in Europe for VET, should be considered as a "teaching philosophy". This means that **learners are put at the core of the teaching process addressing their professional development** where not only the technical proficiency matters, but also employability and critical thinking, preparing them for a dynamic job market.
- Active, student-driven learning fostered by proper methodologies, methods and technology will improve retention and engagement. This is another feature of this learner-centred teaching framework that covers **competency/mastery-based/practical, experiential, work-based, collaborative, reflective and personalized learning.**
- Also, by combining personalized and inclusive learning, **learner-centred, supportive and equitable training environments** may be implemented.

C3. Practical, hands-on learning approaches

- Courses and qualification pathways, independently of structure and delivery models (school-based, online, with WBL, etc.), **should emphasize an experiential learning, meaning that, as far as possible, whole-task, project-based or inquiry-based learning are adopted** to give learners better opportunities for practical, authentic and reflective learning representing the referential competencies and occupational roles in the SEB sector.
- Coherently, the educational technology used (encompassing learning materials, resources and teaching & learning environments), will be chosen and managed to **facilitate the acquisition of both, partial (understandings, skills) and integrated learning (competencies).**

C4. Integration of advanced technology for improved technology-enhanced learning.

- Another aspect of the training is a general blended/hybrid model where presential, distant and work-based components can be combined to configure optimal training solutions, accounting with specificities of the application context. This model is necessarily supported on technology, particularly educational technology impacting the core teaching and learning process.

- **Optimal LMS** for distant/online and flexible learning delivery will be used. By extension, **teaching management tools** should be adopted to ensure quality and efficiency of each component (school-based, WBL, online) of the generic blended model.
- **Digital or computer-based learning tools will be adopted to enhance skill acquisition, improve engagement and increase time-on-task** of "SEB electricians" during skilling, reskilling and upskilling training. In general, these tools will improve (supplement, substitute, scale, etc.) traditional technologies and learning environments (such as workshops, laboratories, learning platforms, etc.), and allow reductions in some investments required, among other affordances.
- **Advanced simulators and other educational technology, such as immersive simulators (XR-based) or AI-driven tools, will be used** to extend individual and collaborative problem solving, self-directed learning, decision-making and other occupational skills development, with safe access to real-like work scenarios and systems, and at reduced costs.

C5. Flexibility and accessibility.

- Flexibility ensures accessibility to the VET offer for different learner profiles, including workers, unemployed, young people and others seeking reskilling/upskilling and initial skilling opportunities in the SEB sector. To ensure this, **VET programs should basically offer modular learning options certifiable** (meaning, occupational relevance, including micro-credentials), **cumulative certifications** (meaning, eligible learning pathways with their prerequisites), and b**lended learning options for better accommodation** to learners' preferable/available times, calendar, place and eventually other constraints. Technology, such as learning platforms that allow easy access to digital materials and support laboratories remotely accessible or advanced proctoring resources, contribute significantly to materialize these flexibilities.

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C6. Learning personalization.

- Learning personalization is a relevant feature of the holistic learner-centred teaching paradigm. In the VET offering and courses for the SEB sector it can be implemented by **adapting some instructional methods, content and pace to meet individual learner needs**, while maintaining compliance with the standardized curricula and formal qualifications. This can be achieved leveraging some flexibilities of the model, such as modularity, stackable micro-credentials, mastery-based approaches (rather than learning subject to fixed timelines) and customization of learning routes in WBL settings.
- Also, tutoring and mentoring are essential for personalizing learning experiences for they generically provide individualized support, guidance, and skill development to ensure learners are retained, progress effectively and get successful. They happen in school-based learning settings and WBL within VET programs. In school-based learning settings, tutoring is usually offered by teachers, instructors, or peer tutors, focusing on content, behaviours and other non-academical aspects. In WBL, mentoring is typically provided by appointed experienced workers, ensuring learners acquire job-specific competencies and desirable work habits in real-world settings. **Tutoring and mentoring should be instantiated in the SEBCoVE's VET model and pedagogical approach.**
- **Technology plays a role in enhancing tutoring & mentoring approaches for a more supportive and personalized instruction**. For example, these technologies may improve effectiveness and scalability of tutoring/mentoring: digital learning portfolios to document mentees' growth and competencies over time, AI-driven learning analytics to monitor learner progress and suggest personalized interventions, virtual mentoring platforms for remote guidance, or XR simulations for mentored hands-on training in school-based settings.

It is worth noting, that these criteria are general and can be used to define a common and innovative methodological stance characteristic of the SEBCoVEs' VET model. However, not all of them will be of application to a particular education or teaching case necessarily.

4.3. Recommended teaching methodologies

Based on the criteria outlined, the following list contain a selection of discussed teaching methodologies in this report, that may support the kind of common methodological transformation pursued within the SEBCoVE's VET model for the SEB sector (independently of how this approach is used in a particular case). These methodologies integrate proven efficacy, learner engagement, educational technology, and industry needs, allowing for an effective, personalized, and future-ready SEB VET training:

Methodologies and methods for fostering different learning outcomes:

- They are fundamental for acquisition of partial knowledge.
- Integrated learning outcomes represent the intended competencies and roles and can be facilitated with integrated (not analytical) approaches.
- Associated technologies. According to the type of learning outcome. For example, simulators for skills development.

Project Based Learning (PjBL)/Whole Task Learning (WTL):

- Indicated for developing integrated learning outcomes.
- Provide opportunities of collaborative and social learning.
- Based on real or realistic Projects and Tasks.
- Specially indicated for school-based training, or more structured training.
- Acquisition, use and completion of partial knowledge can be organized around.
- Associated technologies. Professional resources, management tools, learning spaces as laboratories and workshops, maker spaces for prototypes, etc.

Simulation Based Learning (SimBL) and Scenario Based Learning (SBL)

- Specially indicated for skills development. Physical, cognitive and social.
- Simulation do not require the real system or tool.
- Scenarios support decision-making skills and more social skills.
- Case-Based Learning (CBL) is a sort of SBL.
- Both may be used for collaborative skills.
- Advanced simulations provide immersive features, more engaging.
- Provide opportunities of collaborative and social learning.

- Associated technologies. XR simulators, traditional simulators, technology trainers, process/services simulators, etc.

Flipped Classroom models.

- Overarching models to strength learning and maximize the practical application of acquired knowledge (integrated learning) in-class settings.
- Associated technologies. e-Learning/multimedia materials for pre-classroom study, remote laboratories, simulators, etc.

Gamification.

- Based on serious games.
- Associated technologies. Digital learning, advanced simulations, etc.

Inquiry-based learning approaches.

- Including Problem-Based Learning (PBL) and other instances of experiential or exploratory learning, especially in open-ended challenging scenarios.
- Support research, decision taking, collaboration and problem solving of real issues.
- Support development of social and self-management skills.
- Associated technologies. Professional resources and information, laboratories and other integrated learning environments.

Work Based Learning (WBL).

- Different models or instantiations: internships, industry projects, apprenticeships…
- To acquire, complete, extend… technical and vocational competencies.
- Work under the supervision and mentoring of professionals.
- Remarkably supported on professional tools, persons, information, interactions.

5. Conclusions

5.1. Summary

This report summarizes the findings from desk research on teaching methodologies applicable to the VET programs and training model developed within the SEBCoVE project, aimed to an innovative teaching that contributes to the excellence in education and training for the SEB sector.

The research analysed various evidence-based pedagogical approaches to teaching and learning, emphasizing the importance of competency-based learning aligned with the industry needs and occupational referents, experiential methods for complex integrated learning, and modern educational technology. All these, to enhance technical and vocational training actions and their associated learning experiences from the learners' perspective. Also, the context of this research was the European framework of VET policies.

Based on this study, the report recommends for the SEBCoVE's VET adopting **(1) a holistic learner-centred teaching paradigm,** that can be materialized with innovative features in **(2) technology-enhanced learning methodologies** applicable to **(3) a generic blended or hybrid model of training provision** (meaning the combination of presential, online and work-based components).

Diverse complementary teaching methodologies, such as PjBL, have been suggested that leverage traditional and emerging educational technologies such as digital and advanced XR simulations. Additionally, the report highlights the necessity of strong collaboration between educational institutions and industry to explore how to better instantiate this methodological transformation.

5.2. Next steps

The next steps involve developing, piloting and validating these methodologies within the VET training model and programs of the SEBCoVE project, with a view in dissemination and institutionalization of this good practice.

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