



*Alliance for Batteries Technology, Training and Skills
2019-2024*

Train the Trainer Guidelines



***Handbook for training in the Battery Industry –
Why? What? Where? How?***



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Handbook for training in the battery industry

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Handbook for
TRAINING IN THE BATTERY INDUSTRY
Why? What? Where? How?

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List of Abbreviations and Definitions

À la carte model	...	A learning model where students rather freely choose between activities relevant to the course.
ALBATTs	...	<i>The Alliance for Batteries Technology, Training and Skills (ALBATTs)</i> is an Erasmus+-funded project with the objective of contributing to the electrification of transport and green energy in Europe by designing a blueprint for competencies and training schemes of the future in the battery and electromobility sector.
AI	...	<i>Artificial Intelligence.</i>
Asynchronous Learning	...	Learning which takes place at different times for students enrolled in a course.
ASA	...	<i>Automotive Skills Alliance</i> – A Pact-for-Skills large partnership with the mission to bring together different kinds of stakeholders involved in the automotive ecosystem and to ensure continuous, pragmatic and sustainable cooperation on the skills agenda in the ecosystem. ASA is a Belgian non-profit company formed from the DRIVES and ALBATTs projects to ensure continuity after the projects are finished.
Battery	...	An association of battery cells (usually, some cells are associated in series to obtain a certain voltage).
BESS	...	<i>Battery Energy Storage Systems</i> - enables power system operators and utility providers to store energy for later use and enhance the flexibility of the grid.
Battery integration	...	Battery integration is the process of integrating a battery cell into a complete and fully functioning battery system.
BMS	...	<i>Battery Management System</i> - monitors battery functions, including temperature, voltage, capacity, power consumption, and charging cycles.
BaTT Forum	...	<i>The Batteries Teachers & Trainers Forum (BaTT Forum)</i> is an ALBATTs initiative of bringing together current and prospective teachers and trainers to share ideas, and best practices, collaborate, and deepen their knowledge of the battery sector.
Big Data	...	Extensive datasets, primarily in the characteristics of volume, velocity, and/or variability that, require a scalable architecture for efficient storage, manipulation, and analysis.

Blended Learning	...	The integration of new technology, today often digital ICTs, into conventional teaching patterns, such as classroom-based teaching.
CaBatt	...	<i>Capacity Building for Battery Teachers in Vocational Education and Training</i> is an Erasmus+-funded project with the objective of capacitating VET teachers around Europe with state-of-the-art battery skills and networks, enhancing VET providers' ability to provide quality training for the battery sector.
Carbon footprint	...	A measure of the amount of carbon dioxide and other Greenhouse gases (GHG) released into the atmosphere, caused directly and indirectly by an individual, organization, event or product.
Cell	...	The battery cell is a single unit composed of electrodes, electrolytes, separator, and current collectors. Cells are composed with other cells into battery packs for use in applications, such as vehicles or energy storage units. Common formats are cylindrical, prismatic, pouch or blade cells.
CFD	...	<i>Computational fluid dynamics</i> (CFD) is a branch of fluid mechanics that uses numerical analysis and data structures to analyse and solve problems that involve fluid flows.
Cycle life	...	Number of cycles yielded by the battery (usually measured until the capacity is 80% of the initial capacity of the cell).
CVET	...	<i>Continuing Vocational Education and Training</i> .
DCS	...	A <i>Distributed Control System</i> (DCS) is a computerised control system for a process or plant, usually with many control loops, in which autonomous controllers are distributed throughout the system.
Digital badge	...	A type of credential or micro-certificate which proves the specific skills that a person has gained through a learning experience.
Digital twin	...	A virtual replica of a physical process, such as a production process that is crucial for bridging the development-reality gap in complex industries, such as battery cell production.
EBA	...	<i>European Battery Alliance</i> Project-driven community, which brings together more than 600 industrial and innovation actors, from mining to recycling, with the common objective of building a strong and competitive European battery industry.
EHEA		<i>European Higher Education Area</i>
ECU	...	<i>Electronic Control Unit</i> .

Energy Storage	...	Capture of energy produced at one time for use at a later time to reduce imbalances between energy demand and energy production.
EQF level	...	European Qualification Framework. An 8-level, learning outcomes-based framework for all types of qualifications.
Erasmus+	...	A European Union programme designed to support various education, training, youth, and sports initiatives. Its primary goal is to promote mobility, cooperation, and the exchange of knowledge and experiences across different sectors and regions.
European Green Deal	...	The new growth strategy of the EU aiming to set Europe on the path of transformation to a climate-neutral, fair and prosperous society with a modern, resource-efficient and competitive economy.
European Skills Agenda	...	The European Pillar of Social Rights and, notably, its first principle spelling out the right to quality and inclusive education, training and lifelong learning. The first version came in 2016, and the second came in 2021.
EV	...	Electric vehicles.
Flipped classroom model	...	A pedagogical model is one where students get access to the teaching material, for example, video lectures, texts, or podcasts, before they come to a synchronous meeting, as a classroom lesson.
Gigafactory	...	A massive battery factory producing battery cells, measured by gigawatt-hours (GWh).
HE	...	Higher education.
HMI	...	<i>Human Machine Interface</i> a user interface or dashboard that connects a person to a machine, system or device.
HVE	...	<i>High Voltage Engineering</i> .
Hy-flex model	...	A hybrid learning model where classroom lectures are recorded, and students may choose to follow it either synchronously in the classroom or asynchronously when it is convenient.
ICTs	...	Information and communication technologies.
Industry 4.0.	...	High-tech, highly automated, and complex manufacturing environments that rely on advanced technology. Industry 4.0 is said to be a novel combination of Automation, Internet of Things and Machine learning.
IPR	...	<i>Intellectual property rights</i> .

IVET	...	<i>Initial Vocational Education and Training.</i>
Lean production	...	Six steps required to implement and used to describe each step: sort, set in order, scrub, safety, standardize, and sustain. Create a safe and organized work area.
Li-ion	...	<i>Lithium-ion</i> battery is an advanced battery technology that uses lithium ions as a key component of its electrochemistry.
Li-S	...	<i>Lithium-Sulfur</i> batteries.
LLM	...	<i>Large Language Models</i> - AI algorithms that use deep machine learning and vast amounts of data to understand, summarize, generate, and predict new content.
LOTO	...	<i>Lockout Tagout.</i> Movable locks that can be used to secure energy-isolating components like switches, valves, and plugs.
MES	...	<i>Manufacturing Execution Systems.</i> Computerised systems are used in manufacturing to track and document the transformation of raw materials into finished goods.
MOOC	...	<i>Massive open online course.</i> A model for delivering learning content online to any person who wants to take a course, with no limit on attendance.
MSA	...	<i>Measurement System Analysis</i> - tool for analysing the variation present in each type of inspection, measurement, and test equipment.
NPN/PNP	...	<i>Negative-Positive-Negative / Positive-Negative-Positive.</i>
OER	...	<i>Open Education Resources</i> - teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others.
Paris Agreement	...	The Paris Agreement sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C.
PID	...	<i>Piping and Instrument Diagram (PID)</i> is a detailed diagram in the process industry which shows the piping and process equipment together with the instrumentation and control devices.
PLC-programming	...	<i>Programmable Logic Controller.</i> A PLC programme is usually written on a computer and then downloaded to the controller.

Prompt Engineering	...	An AI engineering technique which encompasses the process of refining LLMs with specific prompts and recommended outputs, as well as the process of refining input to various generative AI services to generate text or images.
PV	...	<i>Photovoltaics (PV)</i> is the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect.
RFID	...	<i>Radio-frequency identification.</i>
Rotation model	...	A blended learning model in which students rotate between learning stations with different instrumentation and design.
Separators	...	In a battery, separators are insulating membranes that prevent short circuits between the two electrodes; in the SSE, the solid electrolyte may also play the role of the separator.
Skills Cards	...	Identification of occupational profiles with corresponding competencies. The Skills Cards developed through the ALBATTs project focus on the battery sector. These cards are later discussed with ESCO, the European Classification of Competencies and _Occupations, for inclusion.
Smart Grid	...	An electricity network/grid enables a two-way flow of electricity and data between producer and customer.
Solid-state battery	...	Uses a solid electrolyte to regulate the lithium ions instead of a liquid one.
Study Buddy	...	A social learning strategy including peers and colleagues following the same asynchronous course.
Synchronous Learning	...	When instructors and students gather at the same time and (virtual or physical) place and interact in “real-time”.
TMS	...	<i>Battery Thermal Management System</i> - keeps cells within an optimum temperature range, and to maintain an even temperature distribution from cell to cell is vital for high efficiency.
TQM	...	<i>Total Quality Management</i> - management practices throughout the organization geared to ensure the organization consistently meets or exceeds customer requirements.
VET	...	<i>Vocational Education and Training.</i>
VUX	...	In this Handbook, VUX refers to Vuxenutbildningen (adult education) in Skellefteå Municipality, Sweden.

Work-Based Learning	...	Learning that occurs in a work environment through participation in work practice and process and is integral to VET.
Wrap model	...	A learning model where students and teacher follow a distributed asynchronous course, such as a MOOC, together as learners and combine the study with follow-up activities and local examination. In this way, a MOOC course can be "wrapped" into a local course.
XR	...	<i>Extended Reality</i> - an inclusive term used to describe a variety of immersive technologies encompassing Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and technologies that have yet to be imagined.
5S	...	A methodology that results in a workplace that is clean, uncluttered, safe, and well-organized to help reduce waste and optimize productivity. The five S' stand for Sort, Straighten, Shine, Standardise and Sustain.

PART I

WHY, WHAT, WHERE AND HOW?

1 Introduction to the Handbook

This handbook aims to assist in developing teaching and training competence in Vocational Education and Training (VET) institutions and to help VET teachers provide training for the European battery sector. It consists of training material and results from the ALBATTs project, which is presented below. Also, it outlines how the training material and other outputs can be used for varying teaching situations and target groups.

In practice, we hope that this handbook will be of help to teachers who are or will be teaching students for actual and future jobs in the emerging battery and electromobility value chain industries. This Greening of Skills¹ is also integral to European climate action policies, aiming at a Net Zero society.

This handbook is intended primarily for teachers in the VET sector. However, university teachers can also use this handbook for their orientation and courses at the undergraduate level, as well as for upskilling and reskilling courses.

The background to the ALBATTs project

The EU aims to achieve ambitious environmental and energy goals, such as reducing emissions and moving towards a more sustainable economy. This is part of the European Green Deal² and the global commitment under the Paris Agreement³ to be climate-neutral by 2050. The growth of the battery industry is crucial for achieving these goals by promoting the use of electric vehicles (EVs) and renewable energy storage.

To reduce Europe's reliance on imported batteries and to establish a strong position in the global battery market, the EU has implemented regulations to ensure sustainability in the battery industry, including eco-design and recycling standards. Efforts are also being made to secure a sustainable supply of essential raw materials like lithium, cobalt, and nickel for battery production, reducing the need for imports.

Some 40-50 large battery factories, known as gigafactories, are being planned or built in Europe to meet the rising demand for batteries, significantly increasing production capacity. This production is complex, energy-intensive, and relies heavily on advanced IT, often called "Industry 4.0.". In addition, the whole value chain of batteries is also evolving, with new raw materials and refining operations, equipment suppliers, recycling and testing companies, and so on.

In pursuit of climate neutrality by 2050, the European Commission's Vice President has estimated a potential shortage of 800 000 jobs by 2025, spanning the whole value chain⁴. Many of these jobs are in manufacturing, with approximately 75-80 % of the workforce in a typical gigafactory being involved in blue-collar roles.

¹ See https://climate-pact.europa.eu/about/priority-topics/green-skills_en where many European initiatives and policies are linked. (Last access 12-03-2024).

² The European Green Deal, available at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (Last access 12-03-2024).

³ The Paris Agreement, available at <https://www.un.org/en/climatechange/paris-agreement> (Last access 12-03-24).

⁴ Speech by EC Vice-President Šefčovič at the press conference following the 5th high-level meeting of the European Battery Alliance, available at https://ec.europa.eu/commission/presscorner/detail/en/speech_21_1142 (Last access 12-03-2024)

The ALBATTs project is a 4-year Erasmus+ funded project running from 2019-2024, including 21 partners from 11 countries. The partnership includes VET institutions, higher education institutions, companies and industry-related associations. The project aims to promote cooperation between all stakeholders in the battery and electromobility value-chain to develop a blueprint for education and training for the battery production sector.

ALBATTs tackles two main questions:



Figure 1 ALBATTs' two focus questions

The project covers the whole battery value-chain from raw-materials and processing to the second life of batteries and recycling. ALBATTs is an [ERASMUS+ "blueprint" project](#) aimed at a "Sectoral cooperation on skills", one of the action points in the [European Skills Agenda 2016](#). This agenda was updated in [2021](#), and the blueprint projects are now part of the ["Pact for Skills"](#) action.

The European Commission funds one blueprint project for each chosen sector of work and business. For example, the [DRIVES](#) project 2017-2021 covered work on skills for the automobile sector (five DRIVES partners are also partners in ALBATTs). A blueprint project gathers skills intelligence, develops a sector skills strategy and action plan, addresses skills shortages and unemployment, and designs concrete education and training solutions for quick take-up at the regional and local levels.

DRIVES and ALBATTs have together formed a "large-scale partnership" under the Pact for Skills. This is the [Automotive Skills Alliance](#) (ASA), a non-profit legal entity in Belgium. ALBATTs training material will be maintained by ASA after the project has ended.

The education systems of Europe are governed by each country. However, the EU wants to stimulate these systems, develop partnerships and mobility between countries, initiate comparisons and cooperation, develop recommendations and promote European development in this way as a way of "soft policy".

Battery Value-Chain

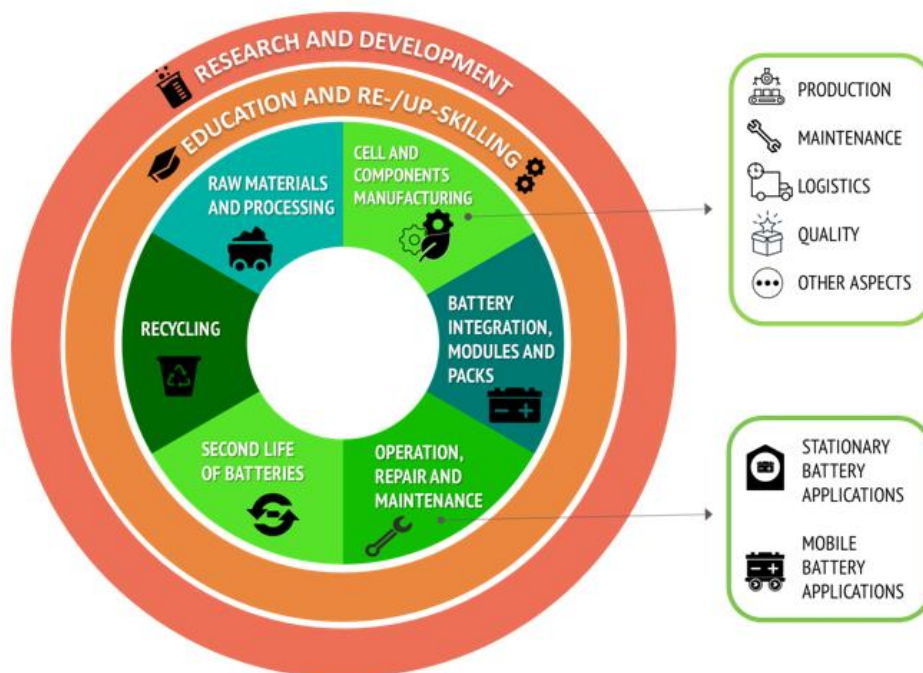


Figure 2 The Battery Value-Chain, by ALBATTs

How this handbook can be used

We hope this publication can be used as a handbook for teachers to get started in educating and training their students for work in the European battery and electromobility value chain. We also think it can be used by teacher educators, school managers and course designers. Another important target group is the internal training facilities in relevant companies. Hopefully, it can also be used as an inspiring example for teachers in the adjacent education fields of green skills.

To provide sufficient training and a skilled workforce, skilled teachers and trainers and educational institutions that are prepared to deliver this training are needed. They need to have sufficient information about what the industry needs, up-to-date learning environments and training material and a network with working life and other educators.

In the ALBATTs project, we carried out desk research, interviews, research, and workshops with experts and the industry and mapped job advertisements for the battery industry around Europe. Our material and recommendations are based on these results.

Input from teachers in battery teacher trainer forums

By spring 2024, the ALBATTs project and its spin-off project [CaBatt](#) have organised three BaTT teachers forums. The aim has been to bring European VET teachers together to increase their capacity to provide training for the battery industry while facilitating the exchange of good practices.

A total of sixty different VET teachers and management representatives from Sweden, Finland, Norway, Denmark, Germany, Czech Republic, Slovenia and Portugal have met up in these forums for a three-day training together with peers and companies.

During the events, there were several workshops and learning cafés where the participants discussed challenges and possibilities within training for the battery sector. Below, we have compiled the most central themes and insights from these discussions.

Question 1. What kind of qualifications, skills, and experience do you think teachers need in order to provide battery training?

Teacher's replies:

- ◆ There is a need for cross-disciplinary skills, as the battery sector requires knowledge of chemistry, process industry, mechanical engineering, automation, knowledge from the electrical field, and good IT skills.
- ◆ Skills in English are necessary in order to be able to utilise material in English and follow what is happening in the industry.
- ◆ There must be an understanding of the entire battery value chain, along with the technological processes, software applications, and safety protocols.
- ◆ Hands-on experience is necessary. The teachers were advocating for opportunities such as job shadowing or apprenticeships within companies.
- ◆ Teachers need tools and methods to develop soft skills among the students.
- ◆ Teachers need cooperation with peers and companies on an international level, as this would increase their capacity.

Question 2. What is the most challenging thing about creating battery education and training?

Teachers replies:

- ◆ The battery industry needs are still almost non-existing in some EU countries, so it is difficult to prepare for training for this sector. It is very unclear if some of the planned projects will actually happen, and the schools do not know if they should prepare and invest in this type of training.
- ◆ The shortage of skilled teachers is a large problem, and there is a lack of training for teachers in this sector, especially practical training.
- ◆ There is a lack of appropriate training material, training material in the right language and training facilities and labs.
- ◆ It is difficult to provide cross-disciplinary training and to include basic knowledge such as chemistry and electrical engineering in courses as the national curricula are very regulated on what is to be taught.
- ◆ There are so many company secrets, and it is difficult to get information from the companies on what skills are needed and what the training should include.
- ◆ A problem is that there is a lack of time for the development of training material and keeping up to date with what is happening in the industry.
- ◆ Artificial intelligence is a challenge but also seen as a possibility for the future that can help trainers to find information and to create training material.

Question 3. How can education and training (trainers, training material, learning environments) for the battery sector keep up with the fast changes in the sector?

Teachers replies:

- ◆ It is essential to have modular and flexible curricula in order to keep up with the fast changes in the industry. In this way, modules can be added or updated whenever needed.
- ◆ It is still a problem in many countries that the process to change the curricula is slow.
- ◆ One of the most central issues is close cooperation with the companies and the equipment providers. This could include frequent meetings on skill needs and processes in the companies, excursions to the companies, on-site training and troubleshooting in the companies, and job-shadowing periods for the teachers.
- ◆ The provision of authentic material for training and manuals from the companies would also be helpful.
- ◆ A good way of bridging is company representatives coming to the school to give training, and the staff from the school is helping with training in the company.
- ◆ Resources, both in the form of working hours to keep up with the development in the industry and investments in equipment and labs, are needed. It is important to remember that basics and fundamentals should not be forgotten, and they do not change as fast.
- ◆ A common platform or channel for teachers with frequent news from battery companies was also suggested. The BaTT-teachers forum was also seen as a good method.

Question 4. When teaching new battery technology, how can you as a teacher create a learning environment that promotes exploration and creative problem-solving among students.?

Teachers replies:

- ◆ Problem-solving has proved to be an essential skill in the battery industry, but teachers were strongly of the opinion that first, the fundamentals are to be taught.
- ◆ After fundamentals, problem-solving skills among students can be developed through project-oriented learning, real working-life cases to solve, VR/AR technology, Gamification, 3D model animation, escape rooms, simulators, digital twins, and flipped classrooms, which could be valuable for developing creative problem-solving skills.
- ◆ Building a unit/factory on a small scale, a mini-pilot plant, together with the students, would develop their understanding of possible problems.

This input and feedback from active teachers have been very valuable for the ALBATTs project, and in this handbook, we are addressing many of these aspects, if not all, in one way or another.

2 The New Battery Value Chain (WHY to teach)

Europe has a whole new industry and value chain in fast expansion: the battery and electromobility value chain. At the time of writing, there are plans for almost 50 battery cell factories in different European countries, and these will all need a qualified workforce, with about 80 % blue-collar workers. These workers will need to be both young people from initial VET education, adult people making a change of their occupations, and experienced people from other industry sectors that need upskilling and reskilling. There is also a need for a highly international workforce since many experts, including operators and technicians, must be recruited not only from European countries but from all over the world. The Northvolt cell gigafactory in Skellefteå, Northern Sweden, has today about 100 nationalities represented among presently more than 2 300 production employees.⁵

There are also other steps in the value chain other than the emerging cell factories that are changing and need to recruit or upskill/reskill their workforce, for example in the automotive industry. An interesting way to keep track of the development of the value chain in various countries is through the European Battery Atlas.⁶

2.1 THE BATTERY VALUE CHAIN

The Battery value chain is composed of the following parts:

Raw materials and processing

This is the 1st step of the battery value chain since it is not possible to produce a battery without specific raw materials. Raw materials such as lithium, nickel, graphite and cobalt are available in nature but have not been so commonly mined in Europe, and now considerable volumes are needed. The high demand for battery raw materials is now an incentive to use other possible battery cell chemistries to lower the cost of batteries and the dependence of raw materials import to Europe.

Processing includes the various refining processes that need to be applied to the raw materials in order to obtain the active materials in their pure form (or with a high percentage of pureness). The mining and refining are often referred to as part of “upstream” production.

Components and cell manufacturing

The 2nd step is the components and cell manufacturing. Here, the materials that form the required anode and cathode will be gathered and mixed in different ways to create a “black mass” or slurry. The components can consist of active materials, conductive additives, solvents and binders. Mixing is usually the 1st step of the manufacturing process of a battery cell, after which many processes take place in pursuance of the electrode manufacturing and the cell assembly and finishing, being the final product of a fully functioning battery cell. To simplify, this step and the following are often called downstream production.

Formation of batteries

After the battery is manufactured, it is tested to check performance and set into “ageing”, and it is trained in a charging and discharging schedule to optimise specified performance. All battery cells that

⁵ Source: <https://northvolt.com/articles/northvolt-2022-where-we-stand/> (Last accessed 12-03-24).

⁶ Source: <https://battery-news.de/en/battery-atlas-europe/> (Last accessed 12-03-24).

perform outside specifications are returned into raw materials again through recycling facilities, often placed close to the gigafactory.

Module and pack manufacturing

The 3rd step is module and pack manufacturing, which refers to the aggregation of various battery cells in a module. A pack is usually referred to as a group of modules powering an electric vehicle, for example. This process can be performed by the battery manufacturer but is commonly done by the vehicle manufacturers so that the battery pack will be custom-made to fit the specifications of the manufacturer and the legislation and also to the constraints of the application (size, power, safety, etc.). Another kind of application is stationary batteries for energy storage. These are made for battery parks in electrical distribution grids, house batteries and emergency battery reserves in hospitals and other critical facilities.

Battery integration

Battery integration is the step that covers the processes of integrating a battery cell into a complete and full-functioning battery system. This means the integration of various components like management ecu's (BMS), connectors, sensors and BUS interface.

Operation, repair, and maintenance

This step, as the name indicates, refers to the active use of the different devices powered by batteries and the respective maintenance and repair in case a problem arises. The main applications integrating battery use are:

- a) the transport sector, such as cars, trucks, heavy machines, aircraft, MCs, scooters, etc.
- b) stationary applications, which include smaller or bigger battery reserves for uninterrupted power supply. Examples are huge battery parks in power distribution grids to house batteries and mobile batteries for remote work.⁷
- c) tool batteries and household batteries.

Recycling and second life

The last step is recycling, or “the second life of the batteries”, being the step that closes the circle of the value chain, making it sustainable. The recycling process aims to recover most part of the materials used in the batteries and reuse them to make new ones. The second life is the name given to a repurposed battery, a battery that came to the end of life on the applications it was sold for and is reused in another application (commonly a less demanding one). There are several projects doing this kind of process. One common way is the disassembly of big EV battery packs and the reuse of some modules in battery energy storage (BESS) or small mobility applications.

⁷ ALBATTs provides sectoral intelligence reports on both mobile and stationary battery applications and trends, see <https://www.project-albatts.eu/en/results> (Last access 12-03-2024).

2.2 THE WORKING ENVIRONMENT AND SKILLS NEEDED IN THE BATTERY INDUSTRY

The working environment in the battery industry can vary depending on the specific factory, company and location within the factory. However, there are some common features coupling with the ***necessary skills related to the working environment:***

- ◆ **Volume production:** Gigafactories are enormous, and employees may have to travel significant distances within the factory to get to their workstations, which can be a physically demanding environment.
- ◆ **Automation Technology:** Gigafactories are high-tech, highly automated, and complex manufacturing environments that rely on advanced technology, often called “Industry 4.0”. Workers may need to operate, monitor, and maintain this technology, including robotics and computer systems.
- ◆ **Temperature control:** Battery production often involves chemical and sensitive equipment that require specific temperature and humidity control. The working area may be air-conditioned to maintain stable conditions.
- ◆ **Safety procedures:** Safety precautions are crucial due to heavy machinery, chemicals, and potential electrical hazards. Workers are typically required to wear personal protective equipment such as helmets, gloves, safety goggles, protective overalls, and steel-toed boots. Safety training is also a key part of the working environment. This also concerns the connected knowledge and competences of the workers.
- ◆ **Clean/Dry Rooms:** Some areas of gigafactories, particularly where battery cells are assembled, are maintained as clean rooms to prevent contamination. Workers in these areas may need to wear full cleanroom suits to maintain a sterile environment.
- ◆ **Shift work:** Gigafactories often operate 24/7, which may require employees to work in shifts, including night shifts and weekends.
- ◆ **Teamwork:** The production process in a gigafactory involves several stages, and teamwork is essential. Workers may be part of a large and coordinated team responsible for different aspects of the manufacturing process. The teams can include employees from many different cultures. Most tasks in a gigafactory are part of a large production process. Collaborative skills are vital for working effectively in a team.
- ◆ **International environment:** The work environment is frequently multicultural, featuring professionals and workers from various nationalities. Cultural comprehension and proficiency in the English language are commonly essential.
- ◆ **Continuous learning:** Workers in gigafactories often require specialized training to safely operate the machinery and equipment. This training can be ongoing, especially as technologies are introduced.
- ◆ **Product Quality Assurance:** Maintaining high quality standards is critical in battery production. Workers may be responsible for inspecting products and ensuring they meet quality specifications. A strong commitment to producing high-quality products is essential. Employees should be dedicated to meeting quality standards.

- ◆ **Career growth:** While many workers in a gigafactory start at entry-level positions, there may be opportunities for career growth, particularly for those who gain specialized skills and experience. A willingness to continuously learn and improve skills is beneficial in a constantly changing manufacturing setting.

A general set of skills can be considered for all positions in the gigafactory:

- ◆ **Technical skills:** A strong understanding of machinery and technology is crucial as gigafactories are highly automated. Employees should be comfortable working with complex equipment and computers.
- ◆ **Attention to detail:** Battery manufacturing requires precision. Employees must pay close attention to details to ensure products meet quality standards.
- ◆ **Problem-solving and troubleshooting:** Recognizing issues or defects in products or machinery is crucial for quality control, and problem-solving skills are essential when addressing problems with machinery or processes. Employees must think quickly, troubleshoot, make decisions, and adapt to changing situations to resolve issues and maintain operational efficiency effectively.
- ◆ **Basic math skills:** Some tasks may involve calculations, so a basic understanding of mathematics is helpful.
- ◆ **Environmental responsibility:** Awareness of environmental impact and following environmentally friendly practices as these companies often aim to be sustainable.
- ◆ **Adaptability:** Gigafactories often use advanced technology, which may change over time. Employees should be open to learning and adapting to new systems and processes.
- ◆ **Communication:** Effective communication with colleagues and supervisors is important for coordinating work and tackling problems.
- ◆ **Physical stamina:** The work in gigafactories may involve standing, walking, or lifting heavy objects; being fit is therefore beneficial.
- ◆ **Reliability and punctuality:** Being on time for the shift is essential to keep production running smoothly.
- ◆ **Time management:** Efficiently managing tasks and deadlines is important to meet production goals.

To summarise, work tasks in a battery production unit, such as a cell gigafactory, demand a range of different qualifications, depending on the production steps. This is a new kind of production in Europe, and a combination of new and old skills is needed.

2.3 ALBATTs SKILLS CARDS

The ALBATTs project has also worked to identify new or changed job roles in the battery sector. We call them “Skill Cards”.⁸ So far, we have noticed over 500 job roles, and we have specified 25 of them as clearly new job roles, of which 11 are on the vocational education levels, EQF 4 and 5. The basis for these skills cards is analysis of job ads in Europe (and in the US for comparison), interviews with experts, expert workshops, and desktop research.

The ALBATTs Skills Cards describe several occupational profiles with corresponding competencies within the scope of battery manufacturing, e-mobility, and stationary battery storage. Each card has a short description of the job role and descriptions of cross-sectoral-specific competencies, sector-specific competencies, general transversal competencies, soft skills and academic competencies.

Companies can use the Skills Cards to identify the needed competencies to 1) readjust/improve employee selection and recruitment, 2) train employees according to the latest sectoral needs, and 3) set up their businesses within the battery sector.

Training providers, such as VET providers or universities, will find them useful in creating training opportunities and improving existing curricula or training programmes. National agencies can use the Skills Cards to create or readjust national education plans. They may also be useful to the general public as a means to learn more about the different jobs in the battery sector.

Please note the following regarding the level of maturity concerning the skills in the Skills Cards:

- ◆ **Awareness:**
Understands the background of the knowledge, competence/skill, and its implications to be able to understand how it is applied in the environment.
- ◆ **Practitioner:**
Strong understanding of the knowledge and experience in the competence/skill. Able to apply knowledge, the experience of the competence/skill and share with others, including tools and techniques, define and use the most appropriate for the solution.
- ◆ **Expert:**
Knowledge, competence, skill, or ability to develop and apply procedures and activities as an individual and/or provide his qualified opinion to a team. Recognised specialist and advisor in the generation of solutions and ideas, including methods, tools, techniques, guiding or leading others in best practice use of the specific knowledge and skills.

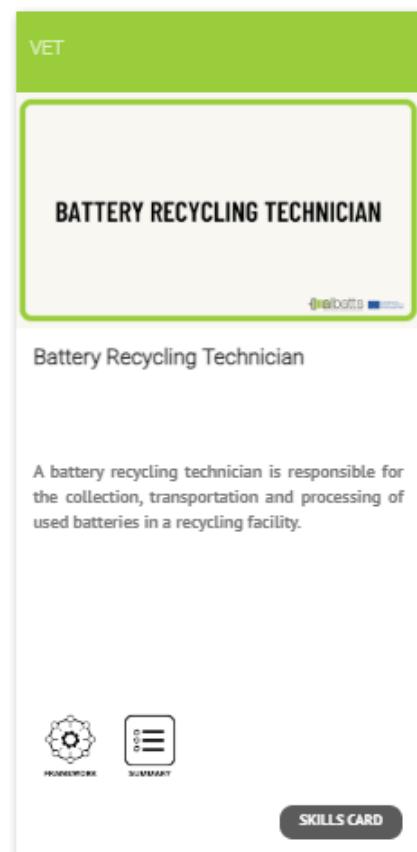


Figure 3 Example of Skills Cards

⁸ See <https://www.project-albatts.eu/en/skillscards> (Last access 12-03-2024).

2.4 DIFFERENTIATION OF LEARNERS

As already mentioned, the battery industry is estimated to need about 800 000 skilled workers by 2025.⁹ This requires that as many different groups of the potential workforce as possible be targeted, bearing in mind the demographic changes in Europe and a lack of workforce. The targeted groups are: 1) Youth going for their initial training, 2) Adults who need reskilling and upskilling, and 3) Immigrants who will be needed in most European countries due to a diminished local workforce.

A differentiation in the education and training of the potential workforce will be needed to meet students' individual needs, learning preferences and abilities. Recognizing and accommodating different ways of studying and learning will be key to attracting and training these different groups of learners.

We have also found that experience from other sectors could prove very beneficial when working in battery production. Experiences from process industries are valuable, such as the production of paper, food, chemicals, production of oil or gas, or processes involving leaching, coating, or concentrators or smelters.

Still, upskilling and reskilling are needed, both before employment and as training at the workplace. This kind of reskilling/upskilling, Continuing Vocational Education and Training (CVET) that is needed is often related directly to batteries and battery cell production as a new application area for skills that workers bring with them. For the education of young people in Initial Vocational Education and Training (IVET), companies primarily ask for education and training in modern industrial methods, IT, troubleshooting skills, etc.

In chapter 7 of this Handbook, we discuss different kinds of learners and their needs in more detail, together with teaching advice for each group.

⁹ Source: Speech by EC Vice-President Šefčovič at the press conference following the 5th high-level meeting of the European Battery Alliance, available at https://ec.europa.eu/commission/presscorner/detail/en/speech_21_1142 (Last access 12-03-24).

3 Curriculum and learning content (WHAT to teach)

European schools and teachers operate within diverse education levels and national systems, each with its unique characteristics. It's important to note that the European Union lacks authoritative control over national education strategies. However, recognizing the crucial role of education and training in development, the EU actively promotes collaboration and development through various initiatives, calls, and projects. This approach shapes a flexible European education policy focused on cooperation and growth.

However, what can be taught in one way in a school in one country has to be worked out in another way in another country.

3.1 FORMING A BATTERY CURRICULUM

In vocational education, which is the primary focus here, the educational providers often have limited possibilities or resources for designing new courses for new regional needs. The national or regional government administration institutes curricula and learning outcomes, often formulated in the form of courses, and it is often only these courses that can be taught and funded within the national education system. The development of curricula at the state level can be slow. At the same time, vocational schools often are willing to listen closely to regional needs and want to start education and training for new jobs as soon as possible.

In higher education, as a comparison, universities can form new subjects and new courses, but this does not make them faster in adapting to new work market needs; in fact, they are often slower.

What publicly funded VET schools can do is be outspoken to authorities about their need for new suitable course plans. While waiting for these course plans, they can choose the most applicable existing course plans and fill them with new examples, work tasks and applications when possible. This is how training cooperation between adult education in Skellefteå (VUX) and the Northvolt Ett gigafactory started. Other countries can have other possibilities.

In the ALBATTs [report D6.4](#), one may find the content of recommended learning objectives related to formulated Skills Cards/job descriptions. Consulting and using this work is a good way to start forming a local curriculum with learning objectives and course and programme plans. For the ALBATTs courses presented below, a text document with learning objectives and other curriculum information is attached to each course.

3.2 LEARNING MATERIALS

When designing and preparing courses, commercially available material or free material can be used besides self-produced materials and content. Here, we give some recommendations of available materials for both students and teachers who are learning this for the first time. The main contribution of the ALBATTs project is the available courses, which are modular and can be used in many ways. See also Chapter 4.6 ALBATTs courses.

Open Education Resources (OER)

An Open Education Resource (OER), also called a “learning object”, is a digital learning material module. OER can be as big as a whole course or just a small or medium-sized component (such as a video, text, simulation, etc.) that a teacher can use when designing course content. A searchable OER

database lists descriptions and links to resources and sometimes hosts them. Most are free to use under a CC license¹⁰. There are numerous OER databases and listings available, but they come and go, and sometimes, learning material disappears or becomes old. There are also various ways of thinking about what an OER is or how it should be constructed, so finding the right learning material is not straightforward.

Some of the biggest and most multifunctional sites are [Merlot.org](https://www.merlot.org), [OERCommons.org](https://www.oercommons.org) and [Skillscommons.org](https://www.skillscommons.org). Unfortunately, there are still few functional European OER databases with more than a few examples of OERs. A new and promising EU database for individual courses and modules was launched in beta version in late 2021 by the [EU Academy](https://www.euacademy.eu), with learning materials produced by EU institutions. The culture of sharing digital resources between education providers is stronger in the US and Canada than in Europe.

There have been several attempts to build a federated search engine, such as Google for OER. The search function closest to this now may be the [Mason OER Metafinder](https://www.mason.oermetafinder.com). On the other hand, [OERCommons.org](https://www.oercommons.org) also searches on some other OER sites and has a rich search functionality for advanced users.

A future vision is an algorithm which could know the needs of a specific teacher and his courses and propose him/her new OERs or updates on OERs used directly in an LMS (in the teacher’s view). This would be a push model of information instead of a pull model. When writing this, in early 2024, there are new possibilities with artificial intelligence (AI) tools to make this a reality, so watch out for this functionality!

Learning material on batteries and electromobility is still hard to find. When found, it is often in the form of recorded lectures at higher levels from universities. This may be because education and training in these fields are also new.

<p>A list of OER sources</p> <ul style="list-style-type: none"> MERLOT OER Commons SkillsCommons Open Yale MIT OCW Initiative MIT OCW Channel MIT Open Learning Library Khan Academy (multilingual) PhET (multilingual) Wiki Educator Wikiversity Open Course Library Open Education Consortium Open University Learning Space 	<ul style="list-style-type: none"> Wikiversity Open Course Library Open Education Consortium Open University Learning Space Edukatico Freevideolectures ASA learning framework (Incl ALBATTs) <p>EU resources and policies on OER</p> <ul style="list-style-type: none"> EU science framework Open edu framework 2016 Open Edu guidelines Open edu publications EPALE OER Policy
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Content sources for education adaption

Teachers or course designers can be happy about finding new material, but instead of wanting to use it as it is, they often want to change or adapt it somehow. This is possible for some types of OERs with

¹⁰ For Creative Commons licenses, see <https://creativecommons.org/> (Last access 12-03-2024).

CC licenses¹¹; derivative works are not allowed for others. Sometimes, this need can be solved by contacting the creator or producing something new inspired by the OER found. It is challenging to balance making these changes and not violating copyright or IPR generally. If new material is produced, a reference to the original object with the comment “created after example of x” can be needed. For more information on this subject, see Part II in this handbook, chapter 8.

Below are some YouTube channels listed that can provide interesting material. When using YouTube videos and similar, it is advisable to do so with a link to the resource. Suppose you copy a video or a bigger part of it and place it within your learning platform as a component of a course. In that case, you will need the creator’s permission. Think also about the risk of this video suddenly disappearing from the web. Therefore, YouTube and Vimeo videos are most practical to use as linked extra material, not as necessary centrepieces in a course. Below are some examples of YouTube channels offering interesting learning material. Sometimes, a video is created directly for educational purposes, and sometimes not, but it is useful anyway. Before using an external resource, watch and be critical, and see, especially if some kind of agenda lies behind it.

<p>Engineering channels Crash course channel Lesic Learn engineering through physics The Engineering Mindset „10 best engineering education channels“</p> <p>Battery/energy storage channels Billy Wu’s Battery basics Panasonic battery education Matt Ferrell on battery technology The Limiting factor Undecided Now You Know Channel Just have a think</p>	<p>EV technology channels Electric Viking E for electric Fully Charged News Munro live LESIC tesla motor LESIC on battery car propulsion EV car maintenance</p>
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3.3 ALBATTs COURSES

Free course material on different aspects related to the battery industry has been produced by the ALBATTs project. In the following section, we will give a short presentation of each course and how to use them.

ALBATTs courses are mapped against three different descriptors:

1. The value chain steps
2. The level (Basic, Intermediate and Advanced)
3. Sector-specific, cross-sector or transversal

¹¹ See <https://creativecommons.org> (last access 12-03-2024) – there is also for most countries a Creative Commons national page adapted to national legislation. Google for Creativecommons and the name of your country.

Additionally, the courses are divided into small modules using the micro-credential approach, where each corresponds to a specific learning outcome, making it more flexible, easy, and faster to update each course's content.

The picture below shows the different courses that were created by the ALBATTs partnership and are available for the community.

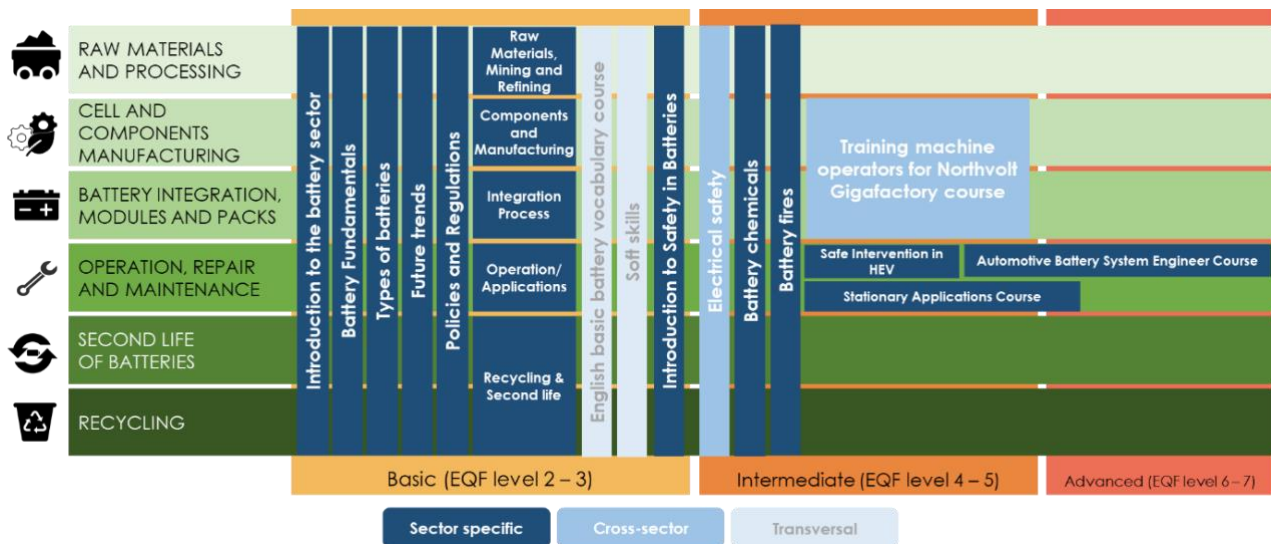


Figure 4 ALBATTs Course structure

For each course, there are two supporting documents available for the teachers on the ASA Learning Platform (more information about the platform follows in section 3.4 below):

1. Syllabus, defining the learning outcomes of the training unit/course.
2. The teacher's/trainer's guide to content, along with the structure and information related to the training unit/course.

Batteries Basics

The batteries basics course gives an overview of battery technology and its value chain and can be used as an introduction course to anyone working or studying in the field.

The course contains the following *10 different training units* that can be delivered individually or combined to create different introductory approaches according to the different training paths:

- ◆ Introduction to the Battery Sector
- ◆ Battery Fundamentals
- ◆ Types of Batteries
- ◆ Future Trends
- ◆ EU Policies and Regulations
- ◆ Raw Materials, Mining and Refining
- ◆ Manufacturing Processes
- ◆ Integration Process
- ◆ Operation/Applications
- ◆ Recycling & Second life

English Basic Battery Vocabulary

The English basic battery vocabulary course comprehends a set of words and exercises to help participants improve their battery-related English vocabulary. It is organized into different training units that can be delivered individually or combined to develop vocabulary according to the different profiles and needs.

Soft Skills for the Battery Sector

The soft skills for the battery sector course comprehend a wide range of learning material for teachers and trainers to capacitate them to help develop soft skills in young people and employees. It gathers content for teachers and trainers to develop their knowledge around soft skills for the battery sector, as well as tools and exercises that they can use in class to develop their students' soft skills.

Batteries Safety

The batteries safety course is an introduction to safety for the battery sector and to the main risks and dangerous associated with batteries. It comprehends the following five different training units that can be delivered individually or combined according to the needs of the different training paths:

- ◆ Introduction to safety in batteries
- ◆ Electrical safety
- ◆ Chemical safety
- ◆ Fire safety
- ◆ Safe intervention in HVE

Training Machine operators for Northvolt Gigafactory

This adult course package is a European prototype for basic adult education for blue-collar employees in Li-Ion cell factories. It is developed with the support of the ALBATTs project in cooperation between VUX, adult education in Skellefteå, and Northvolt Ett in the same city, Europe's first homegrown battery cell gigafactory. The short programme, about 23 weeks, is based on a customised combination of Swedish national courses and does not presently include so much content about batteries but rather on working in a modern process industry. Examples of the courses and training modules combined in the Automation Operator programme are:

- ◆ Industrial processes
- ◆ Remedial maintenance
- ◆ Production Equipment
- ◆ Employed in the Industry
- ◆ Technical English
- ◆ Digitalisation
- ◆ Internal transports (certificates for operating forklift trucks, overhead cranes, and licenses for Hot works handling are included in "Internal transports")

Read more about this course package and its training environments and labs in section 4.1 about learning environments.

Stationary Applications Course

This course will broadly cover a range of subjects, including battery storage developments, applications, safety, and business opportunities. This course will provide students with an in-depth

understanding of energy storage solutions by gaining insight into how to design, obtain and maintain battery energy storage systems, i.e., from sourcing and utilising to recycling.

Automotive Battery Systems Engineer Course

The Automotive Battery System Engineer Course is targeted at System and Software Engineers from the automotive sector coping with the development of whole Battery Systems as well as dedicated Battery Management Systems. The course highlights the importance of Functional Safety and Cybersecurity aspects in the development of Battery Management Systems, as well as the Testing and Homologation procedures for Battery Packs and Systems.

In the table below, it is possible to see the target groups, recommended prior knowledge and teaching methods recommended for each of the training courses developed by the ALBATTs project:

Table 1 Overview of ALBATTs' courses

Course	Target Group	Recommended prior knowledge	Teaching Method
Batteries basics	<ul style="list-style-type: none"> Everyone wants to develop basic knowledge about the battery sector. No minimum EQF level is required. All job roles on the battery value chain are targeted. 	<ul style="list-style-type: none"> Intermediate English level (reading, writing and listening comprehension) Basic digital skills. 	The course is designed for online learning. However, the course can also be delivered in a face-to-face environment or blended learning, led by a teacher.
English basic battery vocabulary	<ul style="list-style-type: none"> Everyone who wants to develop basic battery vocabulary. No minimum EQF level is required. All job roles on the battery value chain are targeted. Specific units for Electricians, Automation, etc 	<ul style="list-style-type: none"> Basic English level (reading, writing and listening comprehension) Basic digital skills. 	The course is designed for personal online learning.
Soft skills for the battery sector	<ul style="list-style-type: none"> Teachers and trainers who want to help their students develop soft skills for the battery sector. The EQF level recommended is 6 or higher. Lower EQF levels may apply according to national requirements for being a teacher and/or trainer. 	<ul style="list-style-type: none"> Intermediate English level (reading, writing and listening comprehension) Basic digital skills. 	The course is designed for personal online learning. However, the course can also be delivered in a face-to-face environment or blended learning, led by a teacher.
Batteries Safety	<ul style="list-style-type: none"> Everyone who works within the battery and/or works with batteries and their materials and components. No minimum EQF level is required. 	<ul style="list-style-type: none"> Basic knowledge about batteries and the battery sector Intermediate English level (reading, writing and listening comprehension) Basic digital skills. 	The course is designed for personal online learning. However, the course can also be delivered in a face-to-face environment or

Course	Target Group	Recommended prior knowledge	Teaching Method
	<ul style="list-style-type: none"> All job roles on the battery value chain are targeted. 		blended learning, led by a teacher.
Training machine operators for Northvolt Gigafactory	<ul style="list-style-type: none"> Adults who want to work as machine operators in a battery plant (Gigafactory). The EQF level recommended is 4. Battery production operators' job roles on the battery value chain are targeted. 	<ul style="list-style-type: none"> Basic knowledge about batteries and the battery sector Intermediate English level (reading, writing and listening comprehension) Basic digital skills. 	More so-called “blended learning” may be appropriate, as many learning tasks need equipment to practice skills, physically present instructors, etc.
Stationary applications course	<ul style="list-style-type: none"> VET students. EQF levels recommended are 4 and 5. Planning, building, maintaining, servicing, and selling, among others, of battery-supported systems job roles are targeted. 	<ul style="list-style-type: none"> Basic knowledge about batteries and the battery sector Intermediate English level (reading, writing and listening comprehension) Basic digital skills Basic knowledge of electrical documentation 	More so-called “blended learning” may be appropriate, as many learning tasks need equipment to practice skills, physically present instructors, etc.
Automotive Battery Systems Engineer Course	<ul style="list-style-type: none"> Students or workers in the automotive sector in a Research and Development department. Minimum bachelor level, master level preferred. Minimum five years of experience in the design of complex systems. EQF level 7 and 8, university degree required. HV Battery Requirements Engineer – E-Mobility, Battery Module Development Engineer and Battery Management System Engineer are examples of targeted job roles. 	<p>The participant should:</p> <ul style="list-style-type: none"> Know the development process for an automotive mechatronic product. Be familiar with terms like system architecture, system testing, and validation. 	The course is designed for online teaching as it provides narrated slides. As the materials are also available in the form of a PowerPoint presentation, the course can also be taught in a face-to-face environment or blended learning.

3.4 THE ASA LEARNING PLATFORM

The ASA (Automotive Skills Alliance) Learning platform <https://learn.skills-framework.eu/> contains several courses offered by the ASA. The battery-relevant courses that were introduced in the previous section are grouped under the [Battery Sector](#) heading.

To enrol in the courses, the participant has to register on the platform and manually enrol in the dedicated course. In the case of the Introduction course, each module of the course is configured as a separate course.

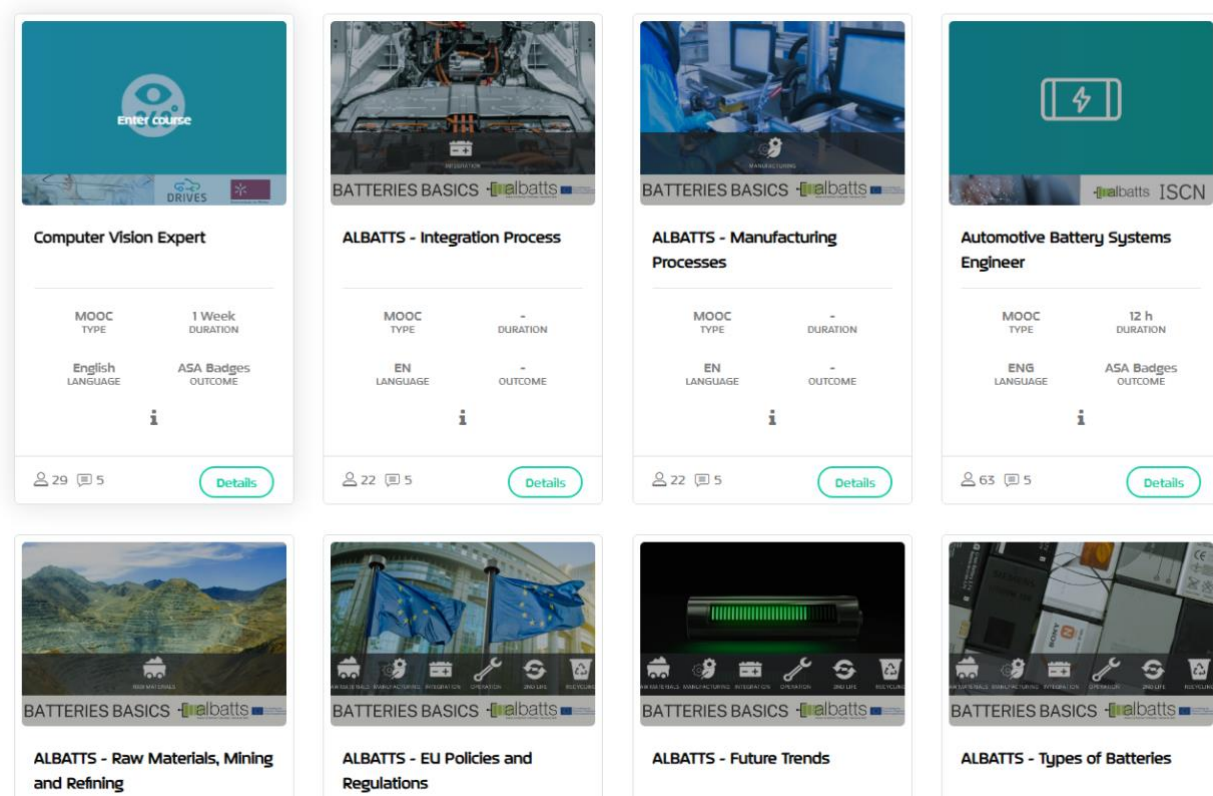


Figure 5 ALBATTs Courses

How to Access the ALBATTs Courses

Go to the ASA learning platform:

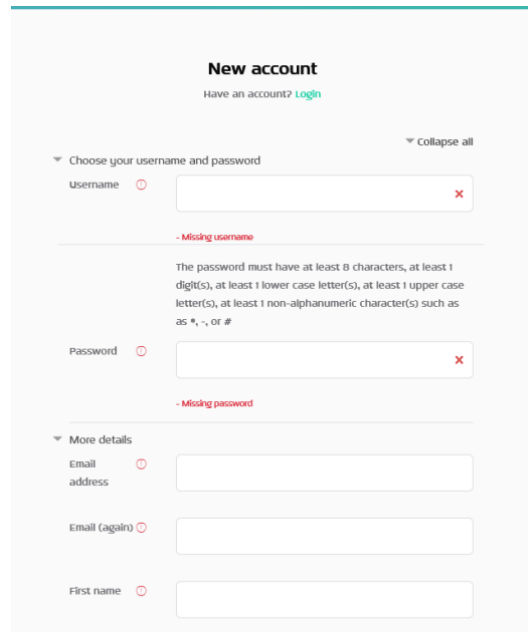
<https://learn.skills-framework.eu/>

Login to your account

Don't have an account? [Sign up!](#)

In order to access the course materials and attend the course, the participant has to register for the course according to the following steps:

- 1 Click on the Login/Register link located in the top right corner.
- 2 Select the option “Don’t have an account? Sign up!”
- 3 Fill out the fields and click on the button “Create my new account”.
- 4 In a few minutes, the participant will get an email from the learning platform to confirm the account.
- 5 Once the participant is registered to the ASA Learning Platform, he/she can enrol to any of the ALBATTs courses.



Roles in ASA Learning Platform¹²

Student

A user with the Student role in the ASA Learning Platform can participate in course activities and view resources but not alter them or see the class gradebook.

When a student first joins, they see all available courses. Once they have enrolled or been enrolled into at least one course, they only see their own courses in the My Courses section of the navigation block or via their dashboard.

Teacher

Teachers can do almost anything within a course, including adding or changing the activities and grading students. By default, teachers can also assign a Non-editing teacher role and a Student role to other users.

In order to assign a user to the role of a teacher in a course, the following steps have to be performed:

- ◆ The user needs to register with the ASA Learning Platform
- ◆ The user must contact the administrator of the ASA Learning Platform in order to assign the teacher role to the user.

Course Administration

In order to administer a course, the participant needs to have the role of a Teacher. With this role, typically, the person can:

- ◆ Update training materials
- ◆ Add reference materials such as articles, YouTube videos, and links to web pages.
- ◆ Administer the discussion forum, e.g. remove posts, add new topics
- ◆ Evaluate the feedback form and export data
- ◆ See the results of the self-assessment quiz
- ◆ See the registered participants

¹² To get more information about the ASA platform or to get involved in further development, please email development@skills-alliance.eu

The Moodle Learning Environment

The ASA Learning Platform is based on the Moodle Learning Management System. Extensive documentation about Moodle and how to manage it is available at:

https://docs.moodle.org/39/en/Main_page

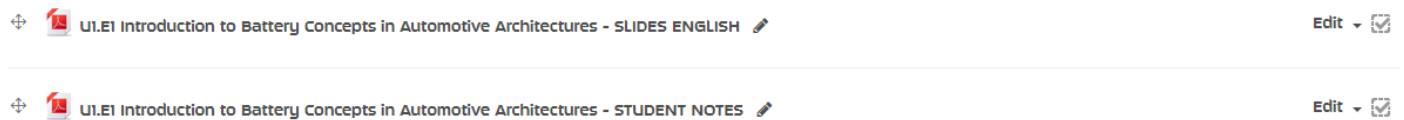
and on the Moodle YouTube Channel: <https://www.youtube.com/@moodle>

Updating or Adding additional content to the course

In order to update existing training materials, the editing has to be turned on:

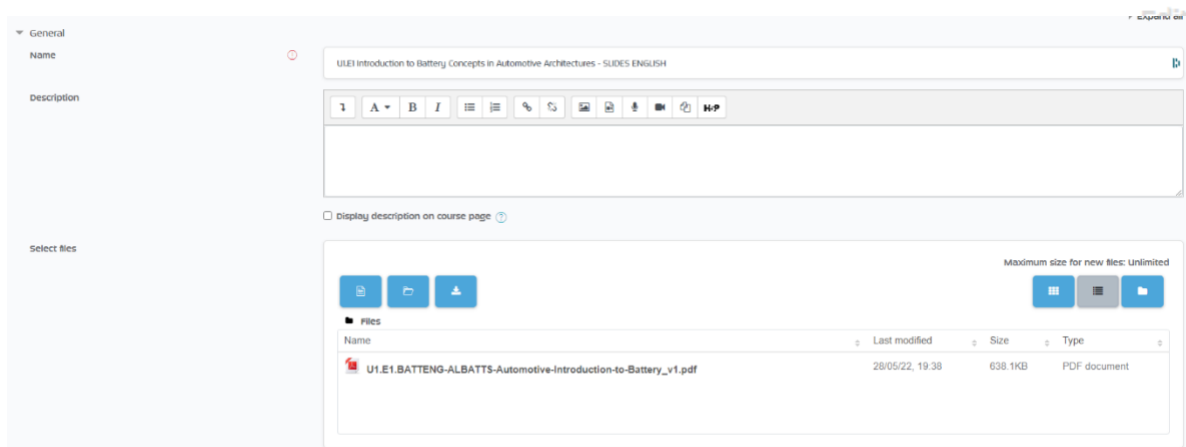
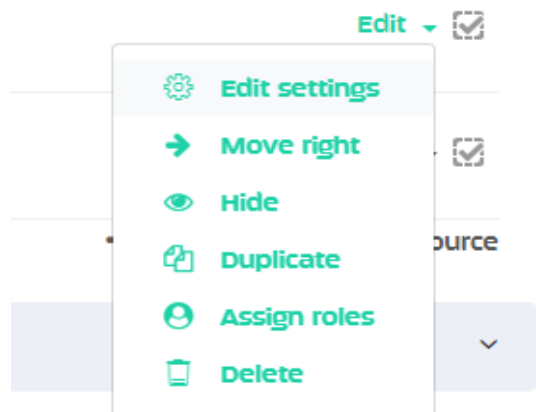
Turn editing on

Next to the content which needs to be updated, e.g. training materials, an Edit possibility appears:

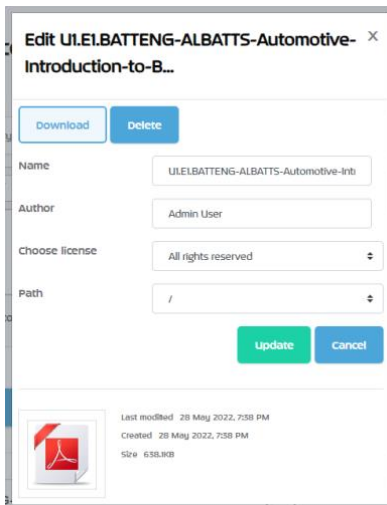



where the participant can edit the settings, hide, duplicate or delete the content:

With the edit settings option, the participant has the possibility to change/update the training materials (in our case, a PDF slide set).



By clicking on the file, additional options appear, such as renaming the file, changing the author, or deleting the file.

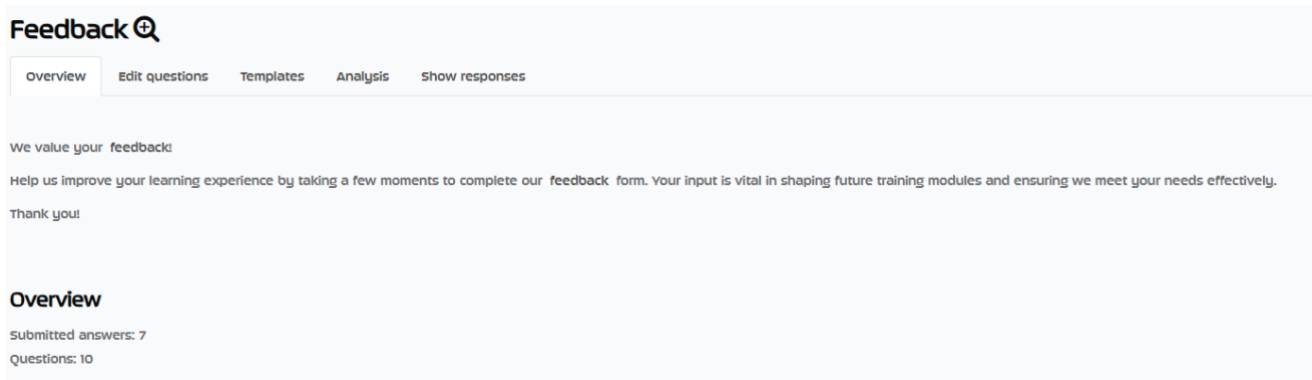


To update or add a new file, click on the upload icon  or drag and drop the file. You can remove the old file or set the new file as the main file:

Evaluation of the course

As a teacher, you can evaluate the course feedback by clicking on the feedback link and then selecting either Analysis or Show Responses.

With the Analysis option, the feedback can be exported easily to excel.



3.5 BEST PRACTICES TO DELIVER A COURSE

Delivering an online course (MOOC)

ALBATTs courses were developed as online asynchronous training, where students can do their work in a flexible way at different times without the supervision of a teacher. Digital tools such as digital texts, lecture recordings, films, online labs and simulations are used to promote interactivity, thus captivating the students to explore all the content. In these cases, it is up to the students to enrol in the learning platform and train at their own pace.

Delivering a blended learning course

Using ALBATTs courses for blended learning experiences is also possible, and it has even been advised for VET students. The flipped classroom model (please see Chapter 4, Learning environments, equipment and material) can be used very successfully with these populations, where the teacher gives the students access to the teaching material, for example, one training unit or chapter at a time, before they come to the lesson. During the lesson, time can be used in a different and more effective way for individual feedback, deeper into the subject, discussion questions and solving problems with the students, or group work.

Delivering an adaptive learning course

During the ALBATTTS project, an adaptive learning course for the Batteries Basic was developed. Realizeit is an adaptive and personalized learning platform that aims to help learners from all backgrounds to achieve their maximum potential in terms of mastery of the material they are trying to learn. The system learns about the learner and adapts to provide everyone with the most suitable experience and content.

Learner progress is continually tracked and evaluated by our intelligent, adaptive system, which allows learners to skip ahead when they demonstrate that they understand the material.

Appropriate interventions are also dynamically delivered to learners when the system detects that they need some help. Instructors or facilitators can also monitor the learners' progress in real-time, meaning that they know when they may need to intervene to help or encourage learners themselves.

In Realizeit, measurement of learner knowledge and capability is key; all recommendations are based on the evidence that is gathered and happens in real-time. That is, the system does not determine a pre-defined path and follows this throughout the learning process. Instead, after every learner interaction, it re-evaluates the learner's knowledge and adjusts the recommended next step accordingly.

The ALBATTTS Basic Batteries course has been implemented in Realizeit, so learners now have the opportunity to experience this course within an adaptive learning framework. Learners and instructors can activate this course by selecting learning objectives or units in the ALBATTTS Learning Management System, at which point they will immediately be brought into Realizeit, where they can access both the content and Realizeit's adaptive technology.

Learners will have the option to start each learning unit by choosing to Determine Knowledge. This operation allows learners to answer questions drawn from throughout the unit and, if they are successful, to be marked complete on lessons without having to work through all of the content. This allows Realizeit to respect the prior knowledge of learners and optimises learner time by removing the necessity of working through material that they already know. If they are successful, their completion will be marked on their learning map, as shown below.

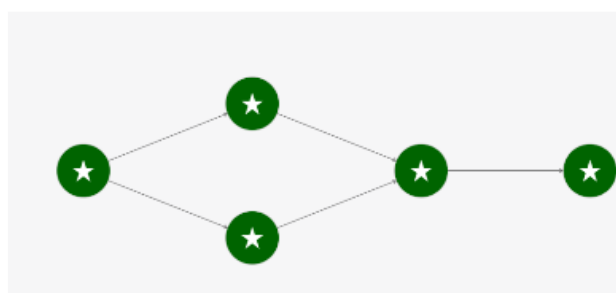


Figure 6 Adaptive learning structure

The learning map is core to the Realizeit experience, providing a visual representation of the learner's progress through a course and showing both the standard of mastery that the learner has achieved on each topic or lesson and the connections between the lessons – the prerequisite network means that learners may have to show completion on a given lesson in order to access the next lesson on the map.

Apart from Determine Knowledge, learners can also select the Learn option to engage with the content in a lesson and answer questions about that topic in particular. Lessons can include content of any kind, including embedded videos or interactive materials of different kinds.

If the learner is struggling to answer questions correctly, the system will deliver recommendations such as revisiting prerequisite material or reviewing the previous unit. Once lessons are complete, learners

can select the Revise button (view all content and questions again) or Practice the lesson (answer questions from the lesson again). These activities can help learners solidify their learning and improve their recall of the material. The system will also encourage learners to undertake these activities in order to improve their scores, if relevant.

3.6 COURSE COMPLETION AND DIGITAL BADGE GENERATION

The system issues the Digital Badges through the Skills Hub (<https://skills-framework.eu/>) used by the Automotive Skills Alliance (ASA). Digital badges are micro-credentials that serve to recognize achieved competence or learning.

Digital badges are a type of micro-certificate that may be shared online to prove competence (learning outcome) on a certain level, and the Automotive Skills Alliance issues it as a large-scale partnership in the automotive-mobility ecosystem under the Pact for Skills. An example of this micro-credential is [Assertion - Skills Hub \(skills-framework.eu\)](#). The overall guide to the ASA micro-credentials is available here: [Wiki - Skills Hub \(skills-framework.eu\)](#).

Badges are organized into 4 layers:

- ◆ Layer 1: Maturity Level – (1) Awareness; (2) Practitioner and (3) Expert Level Badges
- ◆ Layer 2: Concept Type – (1) Skill/Competence or (2) Knowledge
- ◆ Layer 3: Type of Completion – (1) Attendance; (2) Exam
- ◆ Layer 4: Recognition
 - (1) Recognized – certificate/training from recognized entity (by DRIVES project) is provided for the completed training course; (Gold Colour) – based on the recognition criteria
 - (2) Unrecognized – certificate/training is provided from unrecognized entity or not provided at all; (Grey Colour) – or DRIVES colour

Recognition criteria are the following:

- ◆ Conformity Assessment ISO:17024
 - To be specified for certain certificates provided for the training – certification is aligned with ISO:17024
 - Will result in Gold Badges issued upon training completion
 - The emblem is shown in the provider's detailed information
- ◆ ECTS credits:
 - If course completion is connected to the ECTS credits, trainees will obtain Gold Badges
- ◆ EQAVET implementation:
 - This is specified during the provider registration and has no effect on the badges
 - The emblem is only shown in the provider's detailed information

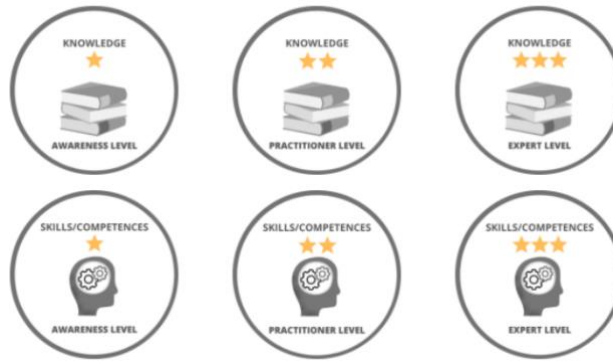


Figure 7 Grey Badges



Figure 8 Golden Badges

After all learning activities are completed, the Digital Badges are issued to confirm that the student has studied all the relevant material or learning sources, including answering the feedback survey.

Students will receive an email informing them about the course completion and about the fact that the badges were issued in the platform - [Home - Skills Hub \(https://skills-framework.eu \)](https://skills-framework.eu). The students will also be given the credentials to log in to the system to access the badges.

4 Learning environments and equipment (WHERE to teach)

Humans learn everywhere and constantly, not only in organised environments. Schools sometimes seem to demand that a skill or theoretical understanding must be learnt and tested within their education classrooms to be approved knowledge, but a workplace seldom cares about that for individual skills. An exception is occupations with certification demands.

Workplace learning

The original historic environment for teaching and learning is the apprentice situation at the workplace – the learner, the apprentice, follows and learns from a skilled person, a master, in his daily work. Research about *situated learning* shows that learning in the environment where the knowledge is going to be applied may be an ideal situation if this kind of apprenticeship works.¹³ The learner’s situation is *peripheral* (not necessary for the master’s activity or production), but the learner is at the same time allowed to participate actively in a legitimate way (as participating in the work) and thereby learns. This learning environment is as old as human learning itself.

Work-based learning is an essential part of vocational education in many European countries. In some countries, most of the training is happening in the workplace. However, in a new emerging industry, such as the battery value chain, where the workplaces do not yet exist or are in the development phase of production, they may not have time for interns and apprenticeship students. The focus is to get the production up and running. In addition, at this stage, there may not be people in the company who can take on the responsibility of training others. When the company and the company is becoming more mature, the company can take responsibility for the training and offer apprentice places and internships. The case has proved to be so, for example, in Skellefteå, where the adult education VUX, on request of Northvolt, has trained many of their workers.

Classroom and learning workshop/lab learning

However, when training needs to be scaled up, there is a limit to the number of learners/apprentices a master can handle and still produce himself. That is why we have constructed learning environments such as classrooms and specialised learning workshops, where the teacher or trainer can regulate the flow of information and organise the teaching and learning activities. Classroom practice can, of course, be combined or “blended” with workshop learning, learning at the workplace, and flexible learning by the use of media.

Media-based personal learning

The evolution of communication, from the invention of writing to print, film, TV, and now the Internet, has significantly reduced the barriers to accessing information. However, it's important to note that merely having access to information does not automatically translate to learning. Media enables learning at home or wherever it suits the learner, but it is just confusing to think of these new technologies as magic tools and think of “cyber” learning or “digital” learning. Learning at the workplace, in the classroom, in a school workshop or lab or at home must be combined to suit the teacher, the learners and the learning objectives. Today, we have all kinds of online platforms and tools to enable flexible learning and learning communication in real-time. It enables many “blends” and combinations of teaching and learning environments.

¹³ Lave, J., & Wenger, E. (1991) *Legitimate Peripheral Participation*. Cambridge University Press. Available at <https://bibliotecadigital.mineduc.cl/bitstream/handle/20.500.12365/17387/cb419d882cd5bb5286069675b449da38.pdf?sequence=1> (Last access 12-03-2024).

4.1 PHYSICAL LEARNING ENVIRONMENTS AND EQUIPMENT

Developing physical learning environments for VET schools can be very costly. Because of the fast development in the industry, the equipment can also become outdated very quickly. Therefore, it is suggested that facilities and equipment that can be used for several industries, not only the battery industry, be invested in. It is advisable to invest in equipment from providers that can provide support, update the programmes, and provide training material and online courses. There are several companies offering training equipment and materials, such as ABB, Siemens, Festo, etc.

If possible, a model where VET schools, adult education, and higher education establishments invest in facilities together with the local industry is recommended. Different days and slots during the day can be used for different organizations, and peer learning and co-creation can be the result of cooperation.

VUX adult education centre in Skellefteå, Sweden, provides training for automation operators, maintenance technicians, quality technicians and up-skilling/re-skilling courses for the battery industry. Skelleftea municipality has invested in learning environments and equipment that are used for this training. The training equipment and facilities are also used by higher education and by Northvolt, training their staff in the evening.

Examples of physical learning environments at VUX in Skellefteå:

Training facility 1

Mechanical training, tool learning, mechanical measurement technology, mechanical drive systems, safety issues, 5S, LOTO, and electrical frequency converter. 19 different practical exercises with increasing difficulty. Training for competencies such as operator, service, maintenance, troubleshooting, etc.

Digital learning portal for individual preparation and learning.

These stations allow for a lot of hands-on training. Based on feedback from former students and companies, this is the most valuable training facility of all the educational environments we provide for studies. The students need hands-on training, regardless of background, and a lot of it.



Left: VUX trainer instructing operators in mechanics



Right: Northvolt trainer shows a new employee how to assemble a mechanical drive system. Training conducted by Northvolt for Northvolt.



The mechanical trainer equipment by Festo Didactic, which has a clear focus on hands-on training, is used for this training. We are using a variety of tools for assembly, measurement, etc., on several different mechanical drive systems. 19 different assembly exercises from basic level to more advanced level with a specified focus depending on education and target group.



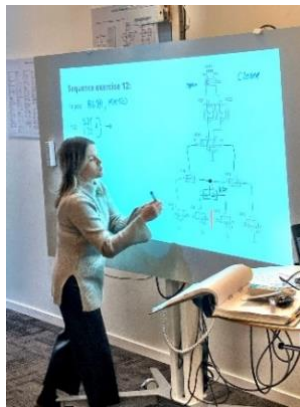
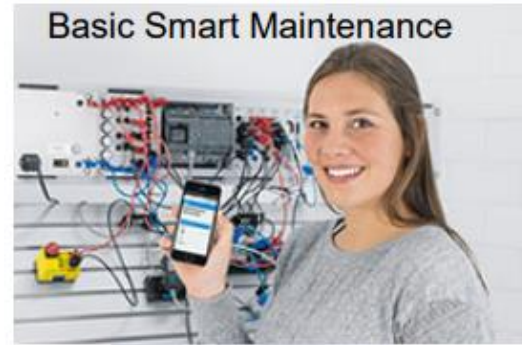
Safety is of great importance and is the spine of every education carried out by VUX in our training facilities. 5S and LOTO are two partial moments taking place as a part of the education based on feedback from companies in the region.

Training facility 2

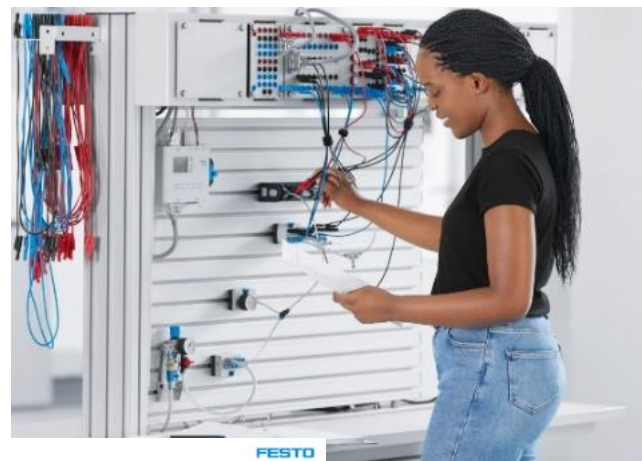
Pneumatics, electric pneumatics, connection exercises, sensor technologies, valves, PLC programming, component knowledge, drawing reading, connected learning, smart maintenance, simulation software, safety, 5S, control engineering logic,

Digital learning portal for individual preparation and learning.

Training for operators, maintenance technicians, quality control, troubleshooting, service technicians, programmers, and automation engineers.



Above: One of our trainers conducts a lesson on schematic drawing and understanding as a preparation for the practical session. Trainers at VUX train prospective operators in pneumatics. Blended learning with theory and practical exercises.



TP 1312 Smart Sensors (8116358)

Includes

- 3 basic IO-Link sensors to teach IO-Link and smart sensors fundamentals
 - Diffuse photoelectric (8110725)
 - Inductive proximity (8110726)
 - Ultrasonic (8110727)
- IO-Link master modules with 4 ports (8110729)
- Accessory kit (cables + tray) (8112723)
- Link to download PACtware (free)

Necessary accessories

- Set of test objects from TP1311 (549830)
- Slide unit from TP1311 (572740)
- Sensor workstation (8110723)*
- Power cord (multiple options available)
- Computer (not included)



Complete TP 1312 Smart Sensors

8116358
Includes all 5 items to the left

*The Sensor Workstation can be replaced with a profile plate and a 24 V DC power supply

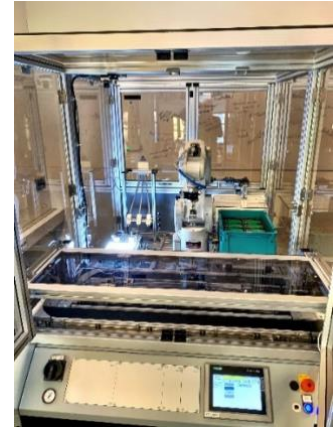


Training facility 3

Factory learning, Industry 4.0 learning, production technology, assembly technology, robot-, PLC-, HMI- programming, quality assurance, LEAN-production, AI, XR, digital twins and factory simulation, HMI-training, MES-systems, RFID process control, vision technology, production line understanding,

Digital learning portal for individual preparation and learning.

Training for operators, maintenance technicians, quality control, troubleshooting, service technicians, programmers, and automation engineers. This education environment is able to be used by higher education students at EQF levels 5-7.



Some of our trainers carry out planning, preparation, and training for operators and maintenance technicians with a focus on production techniques and production equipment on our production line, the “Cyber-Physical Factory”. A big and fundamental part of the training is to make the students feel safe and comfortable in an environment like this. Safety first, of course!



Training facility 4

Process Control Technologies, DCS, process symbols, PID, valves, actuators, control devices, regulator control technology, component knowledge, process line understanding, measurement technology, flow-, level-, pressure-, and temperature control and measurement technologies,

Training for operators, maintenance technicians, quality control, troubleshooting, service technicians, programmers, automation and/or process engineers. The education environment is also suitable for use in higher levels of education, as in EQF-level 5-7.



Digital learning portal for individual preparation and learning.



Students and personnel from several companies are coming to this specific training facility to train, re-skill, and up-skill to different roles on different levels in the control room- and process control knowledge. One of the reasons for this investment is based on a market survey of companies in this specific industry.



Syllabuses for some of the courses used as base for training inside the new green industry

Skellefteå in Northern Sweden is the place for the first home-grown European battery cell factory, Northvolt Ett. Education was developed together with VUX, the public adult education unit at Skellefteå municipality. As VUX is publicly funded, the education provided must be for jobs in the region, not only for the Northvolt gigafactory. However, as Northvolt's first priority was not battery knowledge but rather modern industrial methods and skills, a broader education and training solution was possible.

All courses used in VUX education in Skellefteå are national courses from the Swedish school authority/department (*Skolverket*). Training is conducted on EQF levels 4-5. All courses contain grading criteria adapted to the learning content in the courses. The grades, A to F, are based on these criteria where A-E is passing, and F is not. As national courses are used, their content could be adapted for use in the battery industry and similar industries.

The following are from the Swedish national course plans used:

Production equipment II -100 credits¹⁴

The teaching of the course should address the following key content:

- ◆ Work with and care for selected production equipment and peripherals, such as tools, machines, production modules and control equipment, in accordance with applicable safety regulations
- ◆ Function and construction of relevant production equipment and peripherals
- ◆ Simple functional control and measurements, as well as some maintenance of production equipment and peripherals
- ◆ Simpler dimensioning and technical calculations
- ◆ Applications for relevant production equipment and peripherals
- ◆ Simpler concepts, methods and techniques for industrial production equipment and peripherals
- ◆ Simple technical description for production equipment and peripherals
- ◆ Material properties and the importance of the material for the function and quality of production equipment, peripherals, and products
- ◆ Measurement and documentation of the quality of work performed.

Measurement- and production control technology - 100 credits

The teaching of the course should address the following key content:

- ◆ Logical basic functions for different control technology solutions
- ◆ Discrete measuring sensors, such as inductive sensors, capacitive sensors, optical sensors, and position sensors
- ◆ Relay control of, for example, motors and signal lamps
- ◆ Designations, markings and symbols of pneumatic and hydraulic control and the dimensioning of pneumatic and hydraulic control
- ◆ Connection of pneumatic or hydraulic control circuit
- ◆ Functional descriptions, drawing and diagrams for control engineering installations

¹⁴ Explanation: A week of full-time studies in adult education in Sweden is normally 20 credits, so 100 credits equals five weeks.

- ◆ Commonly used controlled quantities and devices in measurement and control technology, such as lighting, pneumatic and hydraulic valves, relays, contactors, temperature, pressure, and level
- ◆ Commonly used concepts and expressions in measurement and control technology, such as discrete I/O (input/output), relay and transistor outputs, guaranteed response time, road time chart, flowchart, galvanic insulation, NPN/PNP, sink/source, polarity protection and short circuit protection
- ◆ Methods for documentation of control-technical installations, such as the creation of drawings

Measurement- and process control technology - 100 credits

The teaching of the course should address the following key content:

- ◆ Simple control laboratory work with settings of the proportional gain, the integrating time constant, and the derivative effect of the regulator
- ◆ Simple laboratory tests with temperature measurement
- ◆ Connection, control and adjustment of commonly used measurement and control-technical components with concepts such as NPN/PNP, sink/source, polarity protection and short circuit protection
- ◆ Pneumatic or hydraulic valves, the functions, designations, markings and symbols of the stresses and actuators
- ◆ Signal tracking and functional analysis of a simple measurement and control technology facility using measuring instruments, drawings, schemes, data sheets and manuals
- ◆ Basic measurement and control technique concepts, such as step response, ramp response, dead time, time constant, linearity, hysteresis, span, zero, calibration, on-accuracy, repeatability, reproducibility, proportional band, proportional reinforcement, integrative time constant and derived effect
- ◆ Basic measurement uncertainty, its purpose and terminology
- ◆ Basic industrial measurement technology with commonly used methods for measuring temperature, pressure, flow, and level
- ◆ Introduction to testing, calibration and traceability for temperature, pressure, flow, and level
- ◆ Methods for identifying, preventing, and remedying errors in measurement and control-technical installations
- ◆ Methods for documentation of measurement and control-technical work

General automation technology-100 credits

The teaching of the course should address the following key content:

- ◆ Structure, function, and principles for different types of automated systems
- ◆ Different types of risks in automated systems in the chosen area
- ◆ Standards and concepts used when working with automated systems in the chosen field
- ◆ Planning and implementation of work in automated systems
- ◆ Work environment and safety when working with automated systems
- ◆ Various types of diagrams, drawings, and other documentation of automated systems in the chosen area. Interpretation and methods of their production
- ◆ Methods for installation, programming, and commissioning of automated systems in the chosen area
- ◆ Information technology as a working method in the construction, operation, and maintenance of automated systems in the chosen field
- ◆ Preventive and corrective maintenance in automated systems in the selected area

4.2 DIGITAL/VIRTUAL LEARNING ENVIRONMENT AND EQUIPMENT

Education and training on production equipment is a process in which digital tools such as virtual reality (VR) and augmented reality (AR) are practical to use in most modern courses. Apart from technological advancements, a collaborative approach is considered part of the courses to enhance collaboration between participants working effectively in teams and between institutions creating advanced courses together.

VR (Virtual Reality) training offers a safer alternative to live systems training, eliminating the associated danger. This effectiveness can surpass traditional e-learning methods.

AR (Augmented Reality) offers a unique approach compared to traditional training methods, combining virtual reality with a real-life environment. Traditional exams, whether paper or digital, often fail to evaluate trainees' grasp of real-world concepts. While valuable, hands-on assessments lack data on human error and overall performance. AR bridges this gap by combining the strengths of both methods. It subjects trainees to hands-on examinations while capturing crucial data for program improvement. AR recognises errors like incorrect part usage, out-of-order assembly steps, prolonged task completion, or safety risks.

Personal telepresence, by use of telepresence robots,¹⁵ is a way to be present in a remote location in a more empowered way than just a desktop video conference or the use of a surveillance camera. A typical telepresence robot is a screen with videoconferencing abilities connected to a moveable device so a person can represent him- or herself in a remote environment, talk, move around, etc. An example is the Double from Doublrobotics, which uses Segway-like wheels to move around with an iPad on a telescopic rod. A remote teacher can use this to follow student work in a workshop and give instructions or possibly by learners in a kind of remote-apprentice situation.

Factory simulation is essential for more than just manufacturing optimisation; it explores options and enhances communication. For companies using automation, for example, Siemens Digital Industries Software provides an advanced system for battery factory simulation, covering battery modelling, engineering, and consulting services. This comprehensive solution accelerates battery design by virtually exploring variants and assessing multi-level performance, from system simulation to 3D and CFD simulation. Engineers can model various cell chemistries, evaluate battery pack designs, and consider charging, thermal management, and control strategies for optimal vehicle performance.

Remote instrumentation¹⁶ is the practice of running, using, and manoeuvre physical equipment, machines, or scientific instruments at another location by using digital communication. In this way, some lab equipment for learning can be shared between education providers, training institutes and companies.

A digital twin is a virtual replica that enhances classical VR and is crucial for bridging the development-reality gap in the complex battery industry. It visualises numerous parameters impacting cell quality using technologies like artificial intelligence. Functioning as the battery's brain, the digital twin provides real-time information and future insights, enhancing safety and sustainability.

Utilising **Artificial intelligence** (AI) for battery optimisation, particularly in machine learning, can contribute to managing the complexities of battery cell development. The multitude of parameters influencing cell qualities, such as anodes, cathodes, separators, electrolytes, and housing materials, can be effectively addressed by AI. AI enhances manufacturing quality and production efficiency by recognising process parameters yielding desirable outcomes. While the current focus lies on machine learning for process optimisation, there's substantial potential in development, especially when coupled with a digital twin. This integration allows precise adjustments in a controlled digital environment, minimising the need for extensive

¹⁵ For use of telepresence robots in education, see <https://library.educause.edu/-/media/files/library/2009/9/eli7053-pdf.pdf> (Last access 12-03-2024).

¹⁶ For remote instrumentation, see <https://library.educause.edu/-/media/files/library/2006/4/eli7013-pdf.pdf> (Last access 12-03-2024).

experimental matrices. The journey towards fully automated development is underway, aiming to provide application-specific materials and cell designs effortlessly. AI's role in predicting electrochemical properties accelerates development processes, facilitating material pre-selection and exploring novel, underexplored materials.

However, during the years of the ALBATTs project, a completely new AI field launched its tools to the general public. Large language models (LLMs) changed the approach to how we seek and summarise information, and that also heavily influenced the ways we learn and teach. We will dedicate a complete section to LLMs and tools like ChatGPT; see Chapter 8 - HOW? Blend with AI-Large Language Models in Part II.

Let us first look at some of the techniques that were utilized. Below are several examples of new courses in growing business fields where transformation towards electrification is already ongoing, and students with technological companies are working together to simulate tasks and experience real-world examples from companies.

a) Digital Tools – Simulation-based Education for the PV and Storage Optimization Tools

The “PV and Storage Optimisation Tool” is an online tool that enables installers and prosumers (a combination of producer and consumer¹⁷) to evaluate the economic viability of a PV+Storage system. The tool considers parameters such as detailed load and production profiles, electricity costs, supporting schemes, etc. The user enters various inputs: electrical consumption, solar irradiation, PV and battery size, and electricity costs. The tool calculates the Levelised Cost of Electricity, the Net Present Value and the Internal Rate of Return. The tool may be used to estimate the best PV+Storage system sizing from an economic point of view. The “StoRES Living Lab” provides an interactive web platform which displays data collected from the project “StoRES” pilot sites (or any other pilot site provided that the data input is in the same format as that underpinning the tool) and allows users to experiment with different parameters that influence energy storage. Different pilot plants can be compared, and a parametric study is also included to assess the sizing of the PV and the BESS. Under the parametric study feature, the user may modify the size of the PV capacity and the BESS size and observe how the performance rates are affected. For each profile, the following values are represented:

- ◆ PV production power
- ◆ Load consumption power
- ◆ Direct PV power use
- ◆ Power charged/discharged in/from the battery Power imported/exported from/to the grid.
- ◆ State-of-Charge percentage level

Participants in the “StoRES” stakeholders training received a “Certificate of Attendance” for attending a 2-hour training on Battery Energy Storage. The Certificate had the logos of the institutions involved and, therefore, were recognised in their respective countries. The tools should include upcoming technologies, new policies, etc., within participating countries and across other countries.¹⁸

b) Digital Tools at Virtual Practical Training in Engineering Fields

Simulated enterprise for technical work in technology companies is a European Social Fund project implemented by the Ministry of Education in partnership with the Polytechnical University of Bucharest, Politehnica University of Timisoara, Constantin Brancusi University of Targu-Jiu, conducted between 2011 and 2013. The project aimed mainly at increasing the employability of university graduates in terms of

¹⁷ See <https://en.wikipedia.org/wiki/Prosumer> (Last access 12-03-2024).

¹⁸ Photovoltaic Technology Laboratory Offo Research Centre for Sustainable Energy, University of Cyprus. PV Technology - University of Cyprus, in <https://fossy.eu/laboratories/pvtechnology-lab/> (Last access 12-03-2024).

training and development of the practical engineering skills required by employers by developing and implementing an integrated information platform that simulates real working technology companies and hiring specialists from these companies for students' practical training and for developing supporting materials. These goals were accomplished using an innovative tool for Romanian higher education: simulated enterprise.

According to the project evaluation, done from the perspective of all involved actors (companies, universities, students), the results proved to be positive.¹⁹ The companies were pleased that they were able to provide specific training for the students from the first year of study and to accommodate students with a real working mentality about deadlines, internal communication, discipline, etc. In the following year, many of the students participating in the project were accepted by the companies for internships participating in joint project research. Companies are expected to cut down the cost of training for their future young employees, who should be better prepared for their careers. The university was happy to provide better practical training and take advantage of the mentality change for some of the students, who proved to become better motivated for studying and building their future careers.

c) VR Training Simulations

Conducting live training in and around live high-voltage systems is not advisable due to the danger associated with electricity. Instead, virtual reality offers a safer alternative that offers many distinct advantages over real-world training for assessing trainee engagement and applying knowledge to the tasks they need to perform. A global technology leader, Aptiv provides a portfolio of technologies that make vehicles safer, greener, and more connected. Gemba's virtual reality learning platform provides everything needed to deliver successful VR learning in one place. This platform enhances trainee engagement and knowledge application, with VR-trained individuals recalling up to 75% of the learning material within 24 hours.²⁰

d) Battery Factory Simulation Model

Factory simulation is more than a tool for manufacturing process optimisation. It is a way to explore options to communicate and discuss ideas more effectively. For integrators using automation processes in their factories, simulation is essential for business development and satisfying customers. The importance companies place on simulation is evident, as they are committed to incorporating it into their future projects.

One of the most advanced and highly regarded systems comes from Siemens Digital Industries Software. The complex product offers battery modelling, simulation solutions, and engineering and consulting services to accelerate the design and engineering of batteries by virtually exploring the design variants and assessing multi-level performance.²¹ Siemens aims at solutions that range from system simulation to 3D and CFD simulation, covering the wide scope of engineering domains required for battery systems design.

Engineers can easily model various cell chemistry and battery pack designs and evaluate the overall performance in a vehicle context. The battery modelling and simulation solutions also enable us to consider battery charging and thermal management aspects and investigate the best possible control strategies for optimal performance.

¹⁹ Bralic, A. (2016). ICT and e-learning in higher education in Croatia: strategies and current state. In *Central European Conference on Information and Intelligent Systems* (p. 91). Faculty of Organization and Informatics Varazdin. Available at https://higherdecision.foi.hr/sites/default/files/Bralic_ICT%20and%20e-learning%20in%20higher%20education%20in%20Croatia.pdf (Last access 12-03-2024).

²⁰ Aptiv virtual reality business uses: Oculus for business. Aptiv Virtual Reality Business Uses | Oculus for Business, in <https://business.oculus.com/case-studies/aptiv/> (Last access 12-03-2024).

²¹ See <https://resources.sw.siemens.com/en-US/case-study-ifp-energies-nouvelles-batteries> (Last access 12-03-2024).

e) Using digital twins in gigafactories

The digital twin bridges the gap between development and reality, which is otherwise as large for few technologies as it is in the battery industry. An enormous number of parameters already determine the quality and performance of a cell, and the technologies that ultimately interact with the battery introduce many additional variables. All the data in the digital twin can be visualised, and their interaction can be better understood with the help of technologies such as artificial intelligence.

The digital twin gives the battery its brain. It acquires a memory, can provide information about its current status and dares to look into the future. The result pays dividends for the safety of the cell, as well as for the issue of sustainability. After all, with any lithium-ion battery, there is always the question of resources. However, to best ensure a second-life application of a battery, an understanding of what the battery has already accomplished in its previous life is needed. Simply looking at the charging capacity is not enough here.²²

4.3 INTERNATIONAL LEARNING ENVIRONMENTS

An international learning environment offers numerous benefits that contribute to the holistic development of individuals. In addition, it can give the participants an insight into an industry or a company that is being established in their own country but is still not up and running. The international learning environment can then provide them with the necessary knowledge that cannot be acquired in their own environment.

These opportunities can be facilitated through programmes such as Erasmus+ exchanges for students, apprentices, and teachers. These exchanges can take various forms, including internships within companies, attending courses in foreign schools, or participating in diverse learning projects involving collaboration between schools, and schools and companies.

The international learning environment can also be facilitated online, with schools and teachers offering collaborative courses involving participants from different countries. This setup enables teachers to share their expertise while simultaneously learning from one another. This online format allows for a dynamic and global learning experience, fostering cross-cultural interaction and understanding.

Here are some key advantages of learning in an international learning environment:

- ◆ Cultural Diversity:
 - Exposure to a variety of cultures fosters a global perspective.
 - Enhances cultural sensitivity and understanding, reducing stereotypes and prejudices.
- ◆ Language Proficiency:
 - Immersion in an international setting can improve language skills.
 - Enables language learners to practice and develop proficiency in real-life situations.
- ◆ Networking Opportunities:
 - Builds an extensive network of contacts from around the world.
 - Enhances social and professional connections that can be valuable in future endeavours.
- ◆ Critical Thinking and Problem-Solving:
 - Exposure to diverse perspectives encourages critical thinking.

²² CustomCells, The Digital Twin Of A Battery: How It Works. Medium 2023, in <https://medium.com/master-ofbatteries/the-digital-twin-of-a-battery-how-it-works-cd3456b4666c> (Last access 12-03-2024).

- Challenges individuals to approach problems from multiple angles and find innovative solutions.
- ◆ **Adaptability and Flexibility:**
 - Navigating different cultures and systems develops adaptability.
 - Helps individuals become more flexible and open to change.
- ◆ **Global Awareness:**
 - Promotes awareness of global issues and challenges.
 - Encourages a sense of responsibility and engagement with global affairs.
- ◆ **Personal Growth:**
 - Encourages self-discovery and personal growth.
 - It challenges individuals to step out of their comfort zones and fosters resilience and self-confidence.
- ◆ **Career Opportunities:**
 - Enhances employability in a globalized job market.
 - Demonstrates adaptability and cross-cultural communication skills sought by many employers.
- ◆ **Interdisciplinary Learning:**
 - Exposure to diverse academic and professional backgrounds promotes interdisciplinary learning.
 - Encourages a broader and more comprehensive understanding of various subjects.
- ◆ **Enhanced Social Skills:**
 - Develops strong interpersonal skills through interaction with people from different backgrounds.
 - Improves communication skills in cross-cultural settings.
- ◆ **Tolerance and Empathy:**
 - Exposure to diversity fosters tolerance and empathy.
 - Encourages a deeper understanding and appreciation of others' experiences and perspectives.
- ◆ **International Perspective in Education:**
 - Integrating global perspectives into education enriches the learning experience.
 - Provides a more comprehensive and well-rounded education.

In summary, international learning environments offer a rich tapestry of experiences that contribute to individuals' academic, personal, and professional development, preparing them to thrive in an interconnected and diverse world.

5 To train trainers (HOW?)

Teachers or trainers should have the opportunity to engage in continuous learning both prior to and simultaneously with their teaching responsibilities, aligning with the learning process of their students. In university settings, this integration typically occurs through ongoing research within one's field. In the case of Vocational Education and Training (VET) teachers, competence is often rooted in prior work experience in the industry. However, given the dynamic nature of the field and the relatively novel battery sector and value chain in Europe, direct experiences may be limited. Despite this, existing knowledge and skills can be adapted and applied to the evolving demands of the battery sector and value chain. The following outlines possibilities for teacher training and competence development.

5.1 RELEVANT MOOC COURSES

MOOC courses ("Massive Open Online Courses") come in many versions and flavours, and the interpretation of the MOOC concept is very wide. ALBATTs courses are called MOOCs as they are standalone online asynchronous courses. Conventional or classic MOOCs are often provided by platforms that serve several universities. The most well-known of these platforms are [Coursera](#), [Edx](#), [MiriadaX](#) and [Futurelearn](#). A certificate is given for course completion but comes with a fee. However, most MOOCs can often be studied for free and "audited". In addition, a couple of search sites cover most of the various platform's offerings. The one we recommend is <http://classcentral.com>, which also provides analysis, reviews of courses and rankings.

The original and most common use-case of a MOOC is an individual professional in front of his computer, most often a male with previous technical education, following a course of his interest, with some relevance for his job and career. The possibilities, however, are much wider than that. Studying MOOCs can be a tough undertaking, but it is easier to come through if a learner has friends, locally or online, to study with and discuss.

MOOCs can also be utilised in flexible use cases such as the following:

- ◆ *as an element in upskilling and reskilling* for taking a new job or beginning new work tasks
- ◆ *by a study group at a workplace* or in a community learning centre to study a MOOC together and support one another. Each individual studies the course, but there are regular meetings for discussion and support between learners (see "study-buddy" concept below in chapter 5.2.)
- ◆ *as a "wrapped" course* inside another regular local course. A university or other education provider can sometimes validate a learner's MOOC certificate and count it as a local course. Another possibility is to "wrap" a MOOC within another course – to use it as learning material but arrange labs, seminars and examinations locally (see chapter 6 on Blended Learning)
- ◆ *as a "Train-the-teacher" solution*. A teacher going into new fields of teaching can have considerable help by attending MOOC courses to get both new knowledge and ideas for teaching.

Below, we provide some examples of MOOC courses that can be interesting to use in one way or another for upskilling, reskilling, and wrapping by individual learners or groups. These include courses directly on batteries and electromobility, as well as courses on modern manufacturing technology. All course titles are linked. Check a federated MOOC search engine, such as www.classcentral.com, to discover new courses.

<p>MOOC courses on batteries/electromobility, examples</p> <p>Li-Ion batteries: how are cathode materials made</p> <p>Electrochemical Energy Storage</p> <p>Equivalent Circuit Cell Model Simulation</p> <p>Batteries, fuel cells and their role in modern society</p> <p>Battery manufacturing: Trends in Battery Engineering</p> <p>Introduction to Battery Management Systems</p> <p>Battery State of Health Estimation</p> <p>Battery Storage - Understanding the Battery revolution</p> <p>Algorithms for Battery Management Systems</p> <p>Battery Pack Balancing and Power Estimation</p> <p>Battery State-of-Charge (SOC) Estimation</p> <p>Battery Storage Technology: Opportunities and Uses</p> <p>Electric cars, Technology</p> <p>Hybrid Vehicles</p> <p>Electric Vehicles and Mobility</p>	<p>Examples of MOOC courses on modern manufacturing, examples</p> <p>Lean production</p> <p>Six Sigma</p> <p>Applied Scrum for Agile Project Management</p> <p>Transport systems - global issues and future innovations</p> <p>Introduction to engineering mechanics</p> <p>Introduction to indoor air quality</p> <p>MOOCs on transversal Skills, examples</p> <p>Practical Thinking Skills</p> <p>Model Thinking</p> <p>Marketing Innovative products and services</p> <p>Product Management Essentials</p> <p>Technical report writing for Engineers</p> <p>The future of work – preparing for disruption</p>
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5.2 THE STUDY-BUDDY CONCEPT

Studying asynchronous courses, such as MOOCs, is very demanding for the individual. Learning is more interesting and efficient when a social dimension is added. The ALBATTs Study-Buddy concept is a simple recipe for learning together with peers and colleagues in a nice, social and cost-effective way.^{23,24}

This is how to do it:

- a. Choose a relevant learning resource for upskilling/reskilling, such as a MOOC course on batteries.
- b. Form a small group of people that want to study that course. A minimum of 3 to a maximum of about 8 people is a recommended group-size for informal study meetings.
- c. Clearly define that none of the participants is a teacher of the course – people are just organising the social learning experience, a “study circle”.
- d. Appoint an organiser/host, someone who starts the first discussion for the day and ensures that everyone gets the opportunity to talk, brings coffee, etc.
- e. All participants (study buddies) register for the course and study it individually in their own time at home. People can choose the free version (auditing) or the paid with a certificate.
- f. All participants meet regularly once a week for an hour (with some coffee available) and discuss the course content studied the last week: relations to earlier experience, problems, examples, problem-solving, things difficult to understand – and also how to understand English-language concepts involved. This meeting can also be a synchronous video meeting on ZOOM, Teams, or something similar; it fills the same function.

²³ See Norberg, A., Händel, Å., & Ödling, P. (2015). Using MOOCs at learning centers in Northern Sweden. *International Review of Research in Open and Distributed Learning*, 16(6), 137-151. Available at <https://www.erudit.org/en/journals/irrodl/2015-v16-n6-irrodl05030/1066294ar.pdf> (Last access 12-03-2024).

²⁴ The Study-Buddy concept is a modern version of the Swedish “Study Circle” in the folk movements from the beginning of the 20th century; A group learning together with a learning objective and a material but without a teacher.

- g. If possible, organise an extra session, such as meeting with a local expert or remote expert online or a study visit to a company relevant to the course. This gives an extra dimension.
- h. Conclude the course together with the last meeting. Some participants take the tests and the paid exam, while others take them out of curiosity and learning. Celebrate your success!

While this study-buddy recipe is not as flexible as studying a MOOC course on one's own, it is very helpful to get through the course. Suppose an individual attends a course by himself/herself. In that case, it is very easy to just stop and save it for later when problems with time, motivation or course content arise. In a group of study buddies, the individuals make a social investment to finish the course together. Help is available through group discussions and peer learning; the regular meeting schedule helps motivate.

5.3 METHODS FOR WORK-BASED LEARNING IN THE INDUSTRY

Work-based learning in the industry can be highly beneficial for VET teachers and trainers. As these educators play a critical role in preparing students for careers in various industries, gaining real-world industry experience can help them stay up to date with industry trends, refine their instructional techniques, and better understand the needs of both employers and students.

Work-based learning can be conducted through several arrangements, such as industry placements, internships, mentorship programmes, participation in industry projects, attending industry conferences, or through collaborating with local businesses and employers.

By combining theoretical knowledge with practical experiences, VET teachers and trainers may continuously improve their instruction methods and stay relevant in the ever-evolving field of education.

The benefits are several:

- ◆ *Enhanced industry knowledge*

Industry-based experience allows teachers to stay current with the latest industry practices, technologies, and developments. This first-hand knowledge is crucial for delivering relevant and up-to-date training to their students. Industry experience can help teachers enrich their teaching materials by creating industry-specific resources, case studies, and real-world examples.

- ◆ *Improved instruction*

By working in the industry, VET teachers and trainers can make their instruction more relevant and practical. They can relate classroom learning to real-world applications, which can improve students' engagement and understanding. Teachers can better emphasize the development of employability skills such as communication, teamwork, problem-solving, and adaptability when they have first-hand knowledge of what employers are looking for in job candidates.

- ◆ *Networking*

Building relationships with industry professionals during work-based learning can lead to valuable networking opportunities. These connections can be useful for accessing guest speakers, industry partnerships, and work placement opportunities for students. VET teachers and trainers can provide better guidance to students about potential career pathways, job opportunities, and the skills and qualifications needed to succeed in the industry.

It would be essential to provide teachers and trainers with the opportunity to gain work-based learning in the battery industry and thereby get an understanding of the battery industry itself, the technology and

equipment used, understand the processes, safety aspects, quality requirements and the nature of working in the battery industry.

However, based on our project experience, involving teachers in work-based learning periods or job shadowing in the emerging battery industry appears quite challenging. This difficulty arises from the prevalence of numerous business secrets within the industry, and companies are primarily focused on initiating and optimizing production processes, leaving little time and space for accommodating visiting teachers and trainers. It is crucial to communicate to the companies the significance of their role in training teachers for the battery industry.

Therefore, we advocate for schools to initiate collaboration with companies in their region at an early stage. Some of these companies have research and training facilities dedicated to their own staff, and these facilities could potentially extend their training programs to include teachers. Building such partnerships early on can create a conducive environment for knowledge exchange and mutual support between the education sector and emerging industries.

5.4 INTERNATIONAL OPPORTUNITIES

International experiences could prove highly valuable for VET teachers and VET schools in order to increase capacity to offer battery education. They may get the opportunity to visit battery companies, make company contacts, and explore learning environments and training material for the battery industry through international partners. In addition, they can be exposed to diverse teaching approaches and cultural perspectives, and the teacher may establish professional connections and networks with teachers, trainers and experts from different countries, which may lead to collaborative projects and shared resources.

Exposure to international perspectives can give the teacher updated knowledge on industry trends, help VET teachers provide a more global perspective in their teaching, and prepare their students for the international job market. Teachers can incorporate innovative techniques, technologies, and approaches they learn from international courses and workshops into their teaching, making their lessons more engaging and effective. Funding and support can be found through international education initiatives, such as Erasmus+. ²⁵

Today, many vocational schools around Europe have their own Erasmus+ mobility programmes that can fund these activities. Erasmus+ for vocational training provides opportunities for individuals, including VET learners, apprentices, teachers, trainers, and staff, to undertake mobility experiences abroad. This can include different staff mobilities such as job shadowing, teaching assignments and training courses in other countries. This mobility programme is designed to enhance the skills, knowledge, and teaching methods of VET teachers, ultimately benefiting their students and vocational training programmes.

◆ *Job shadowing*

International job shadowing is a specialised form of professional development that allows VET teachers to observe and learn from their counterparts in vocational training institutions or companies in foreign countries. This experience can be tailored to the unique needs and challenges of VET teachers and focuses on improving the quality of vocational education and training programmes.

◆ *Teaching/training assignments*

²⁵ See <https://erasmus-plus.ec.europa.eu/erasmus-programme-guide> (Last access 12-03-2024).

International teaching assignment is where teachers and trainers travel to another country to deliver instructional content or training in their specific vocational field. This could take place in a foreign educational institution, such as a vocational school, college, or training centre. Through teaching abroad, the teacher will gain a broader perspective on education and exchange knowledge, teaching methods and practices with colleagues in another country.

◆ *Participation in courses and workshops*

Teachers can also gain valuable experience through participating in international courses and workshops. These events provide a platform to learn more about specific topics, best practices and innovative teaching methods from international experts and educators. Teachers can use such arrangements to build networks and bring new knowledge and ideas back to their classrooms.

There are several ways of finding a partner institution abroad for staff mobility. It can be achieved through exploring the home institution's existing professional and academic networks, by creating contacts when participating in international forums, or through online research. Most institutions or organisations have an international office or contact person who may assist.

A well-matched partnership can yield significant benefits for both parties. Communicating clearly, being open to collaboration, and working collaboratively to achieve shared goals is essential. Sharing experiences and insights gained from international collaboration is equally important. When teachers and trainers share their international experiences, students can gain insights into the global job market and the importance of acquiring skills and competencies that are in demand internationally. Sharing experiences creates opportunities for peer learning and knowledge exchange among teachers, promoting a culture of continuous improvement and professional growth. It can also result in internships for students in battery-related companies abroad.

More information about the possibilities within Erasmus+ can be found by contacting [your National Erasmus+ agency](#).

International Teachers' Forum Model: BaTT Forum

Due to challenges encountered in organising work-based learning and gaining access to companies' premises, the ALBATTs project sought an alternative solution. Consequently, we established a forum called The Batteries Teachers & Trainers Forum (BaTT Forum), where VET teachers could collectively learn, exchange experiences, and gain access to company visits as a large visiting group.

The BaTT Forum's primary objective is to bring current and prospective teachers and trainers together to share ideas and best practices, collaborate, and deepen their knowledge of the battery sector. Two events have already been successfully conducted through the ALBATTs project.

The BaTT Forum is currently funded and further developed through the Erasmus+-funded project *CaBatt - Capacity Building for Battery Teachers in Vocational Education and Training* (2023-1-FI01-KA220-VET-000160282). The goal is to evolve into a sustainable model offering Erasmus+ courses for VET teachers, open to all and eligible for VET schools' Erasmus+ Mobility funding. Schools that have their own Erasmus+ mobility funding can allow teachers to participate in high-quality Erasmus+ training courses and pay for travel and subsistence as well as up to 80 EUR per participant per day in course fees (max 800€). Using this funding, the BaTT Forum can also be arranged in the future, outside of any cooperation project, as participation fees can cover the training arrangement.

The following needs are addressed when arranging BaTT Forum Courses:

- ◆ The need for sustainable, high-quality training for teachers in the battery industry
- ◆ There is a need for VET teachers in the battery sector to acquire English and multicultural skills
- ◆ The need to provide an understanding of the battery sector at a European level among VET teachers
- ◆ The need to facilitate networking and collaboration among VET teachers in the battery industry
- ◆ There is a need to grant VET teachers in the battery industry access to visiting companies within the sector
- ◆ The need to provide European recognition of teachers' competencies to train in the battery industry through badges
- ◆ There is a need to disseminate the results of the ALBATTTS project and pilot micro-credentials for the European battery industry

BaTT Forum Erasmus+ Courses will:

- ◆ Bring together teachers from various EU countries and disciplines to gain state-of-the-art knowledge about the industry and build networks with peers and companies
- ◆ Facilitate the improvement of teachers' English and multicultural skills through international courses conducted in English.
- ◆ Provide teachers with opportunities to receive presentations from experts and visit companies within the battery sector. This exposure enables the transfer of theoretical knowledge into practical application and fosters a deeper understanding of industry practices.

A private LinkedIn group has been established where teachers and trainers can access and share information related to teaching for the battery Industry. All interested teachers and trainers are invited to join the group at any time (look for Batteries Teachers & Trainers Forum and ask to join).

Taking part in national and international projects

By taking part in national and international projects, the participating schools and teachers will learn and develop the knowledge and skills for the battery industry. Traditionally, cooperation between VET schools and higher education establishments has not been so common. Through cooperation, the VET schools can receive a great deal of knowledge and material that can be converted to the VET level. In addition, the different educational levels can learn from each other's way of delivering course applications used, and they can develop training material and methods together.

Regionally, they can also develop learning environments and laboratories together, co-create, carry out peer learning and share costs. This can also give higher education teachers and students the possibility of more practical and work-based training.

PART II: HOW?

DEEPER INFORMATION

6 HOW? - "Blended Learning"

6.1 A CONFUSING CONCEPT?

First, a little about the confusing term “blended learning” (BL). It can be argued that BL is more about teaching and teaching organisation than it is about student learning²⁶, although the aim is to enable student learning in the best way possible. In today's education language and some research literature, “teaching” is often called “learning”. Researchers have named this confusing habit as the “learnification” of education²⁷. But teaching and learning are different – if they were the same thing, we would have already solved most pedagogical problems. All that is taught is not automatically learnt, far from. We often do not know exactly how individual students use different kinds of media and communication to learn. BL, in essence, is primarily about the organisation of teaching to benefit student learning. Student learning is a personal psychological process, and the organisation and instrumentation used for teaching to enable or assist learning is something else.

Furthermore, “learning” is not usually anything to “blend”. It is a so-called category mistake²⁸. What can be blended is teaching environments, instructional media, events during the course duration, flexible and less flexible course parts, etc. In the same way, there is hardly any “distance learning”. Distance teaching, on the other hand, makes sense. Using such technology-enabled teaching, the student can, in principle, learn wherever he may be. There is nothing distant about that – he or she learns where he or she happens to be but is helped by flexible teaching— enough about this.

The expression “blended learning” was first used in the 1980s to combine school-based learning and learning at the workplace within the UK Open University.²⁹ Today, “Blended learning” is not a one and only thing – numerous definitions and models can be somewhat confusing.

In a nutshell, BL is about the design of teaching by combining existing teaching methods and strategies with new technology, thereby making teaching more adapted to student needs. This differs from the more radical “all online” agenda, which does not value and use the teacher's existing knowledge and experience.

6.2 BLENDED LEARNING STRATEGIES

Blended learning can work together with most pedagogical methods. It is based on existing teaching practices but integrates new, today often digital, technologies, content and platforms into a new mix, developing new normalities of teaching.

It is common that BL is thought of as “half-distance” or “half-online” teaching, or sometimes as “half-technical” or “half-digital” – thereby thinking of physical place (classroom, distance, online) as the basis of the blend (students and teachers transferring between remote places and the classroom, or between an online cyber-world and an old physical-social world). Some think instead of “technology” as the crucial thing

²⁶ See Oliver, M. & Trigwell, K. (2005). “Can ‘blended learning’ be redeemed?”, *Elearning*, 2(1), 17-26. Available at https://scholar.google.com/scholar?output=instlink&q=info:u_7y-Q8ua_4J:scholar.google.com/&hl=sv&as_sdt=0,5&scillfp=18110060513981523104&oi=lle (Last access 12-03-2024).

²⁷ Biesta, G. (2015). What is education for? On good education, teacher judgment, and educational professionalism. *European Journal of Education*, 50(1), 75-87. Available at <https://bura.brunel.ac.uk/bitstream/2438/10509/1/Fulltext.docx> (Last access 12-03-2024).

²⁸ Bradford, G. R., & Norberg, A. (2021). Negotiating the Blend. In *Blended Learning* (pp. 269-281). Routledge. Available at https://www.researchgate.net/profile/Anders-Norberg/publication/353894303_Negotiating_the_Blend/links/6159fd9a61a8f46670ac6aad/Negotiating-the-Blend.pdf (Last access 12-03-2024).

²⁹ Sharpe, R., Benfield, G. & Francis, R., (2006). The undergraduate experience of blended e-learning: a review of UK literature and practice, *The Higher Education Academy*. Available at https://www.heacademy.ac.uk/system/files/sharpe_benfield_roberts_francis_0.pdf (Last access 12-03-2024).

to "blend" with "no technology". (Example: "We do not need technology as we are all here in the classroom"). However, these ways of thought, place-based blends and technology blends, can be less helpful than thinking about the design of the teaching-learning process in "time" as the basis of BL. We will here describe "time-based blended learning"³⁰, which includes most BL concepts by being on a general level. Then, we will leave some advice to teachers based on this approach.

Time-based blended learning is not complicated; all teachers know it by heart: we meet with students for interactive teaching/learning, checking learning progression at the same time, and then, after the meeting, we give homework, or we expect students to do assignments, readings etc on their own before a deadline – as before next meeting or the end of the course. This is the synchronous-asynchronous shift.

Here, we need two terms to clarify time-based blended learning. They look complicated but are not:

1. **Synchronous** - what teacher and students do at the same time, at the same place or not, digitally assisted or not. Besides the classic classroom as a tool for synchronous communication, we have video conference platforms, online chat, audio conferences, and other new tools that support real-time interaction today. The essential function is very similar between older ICTs (Information and Communication Technologies), like a classroom or lecture hall, and new ICTs, like Zoom or Teams meetings. Both are synchronous and interactive and enable teaching and learning in real-time. (The classroom itself is an ICT, although old, as it regulates social information flows to benefit learning.)
2. **Asynchronous** – what students do in a more flexible way at different times, such as flexible, practical homework, readings, some group assignments, text-based communication, etc. Tools for asynchronous technology have developed a lot with new digital technology. Once in medieval times, teachers and students had no asynchronous ICTs at all – then followed paper and pen, printed books, etc – which is now old technology, well blended into teaching and learning. Now, we have numerous new digital tools: Learning platforms, digital texts, lecture recordings, films, online labs, and simulations are some examples. But these are asynchronous and flexible, and the students do them when they have time within a time frame – which demands discipline and is demanding. A purely asynchronous course, such as a MOOC course, is thereby very demanding, and many students procrastinate their work and fail to complete it in the end or finalise it with a lot of stress before deadlines. But suppose we can blend and balance synchronous course elements and asynchronous course elements. In that case, we can get a flexible course where synchronous components (meetings, interactions) regulate the student's asynchronous work.

Let's then think of practical teaching/learning possibilities in these time-place categories:

1. **Synchronous, co-located teaching/learning** (as classroom-, lab- or workshop teaching). Teachers and students meet in a physical classroom environment for lectures, interaction, work and discussion. This allows personal contact between the teacher and the students and between students. However, students and teachers must be co-located, which is expensive, and today, it is not always necessary to listen to a one-way lecture as an example (which can be done asynchronously instead of recorded). *Same place, same time.*
2. **Synchronous teaching (not co-located)**: With Zoom, Teams or other video conference tools, chat, audio calls or synchronous interaction, students and teachers meet and interact in real-time. This

³⁰ See Norberg, A., Dziuban, C. D., & Moskal, P. D. (2011). A time-based blended learning model. *On the Horizon*, 19(3), 207-216, available at <https://www.diva-portal.org/smash/get/diva2:706050/FULLTEXT01.pdf> and Dziuban, C., Graham, C. R., Moskal, P. D., Norberg, A., & Sicilia, N. (2018). Blended learning: the new normal and emerging technologies. *International journal of educational technology in Higher education*, 15, 1-16, available at <https://link.springer.com/article/10.1186/s41239-017-0087-5> (Last access 12-03-2024).

can, in most cases, replace classroom teaching if needed. These meetings can be used to regulate and motivate flexible asynchronous student work. *Same time, different place.*

3. **Asynchronous teaching and learning:** Students use various digital and non-digital resources, such as books, practical home assignments, learning platforms, online courses, collaboration tools, video lessons, web-based exercises discussion boards, group assignments and online quizzes to complement their classroom or video-conferenced teaching. This gives the student the opportunity to learn at his or her own pace and in their own time. Very flexible but also demanding for students. *Different place, different time.*
4. **Asynchronous co-located learning:** Sometimes, especially in vocational training, students can have flexible access to workshops with equipment under their own responsibility to use in their own time to practice skills, solve assignments, make constructions, etc. *Different time, same place.*

An easy and practical way to think about blended learning is to focus on the teaching and learning process in time, as *a teaching and learning process where synchronous events are blended with asynchronous events*, with a carefully chosen mix of old and new tools.

We meet – and then do work on our own – and meet again – and progress until a deadline in that way. A *social learning expedition in time*. Actually, the classic lecture sessions and book reading in between are, in this way, also a kind of blended teaching and learning.

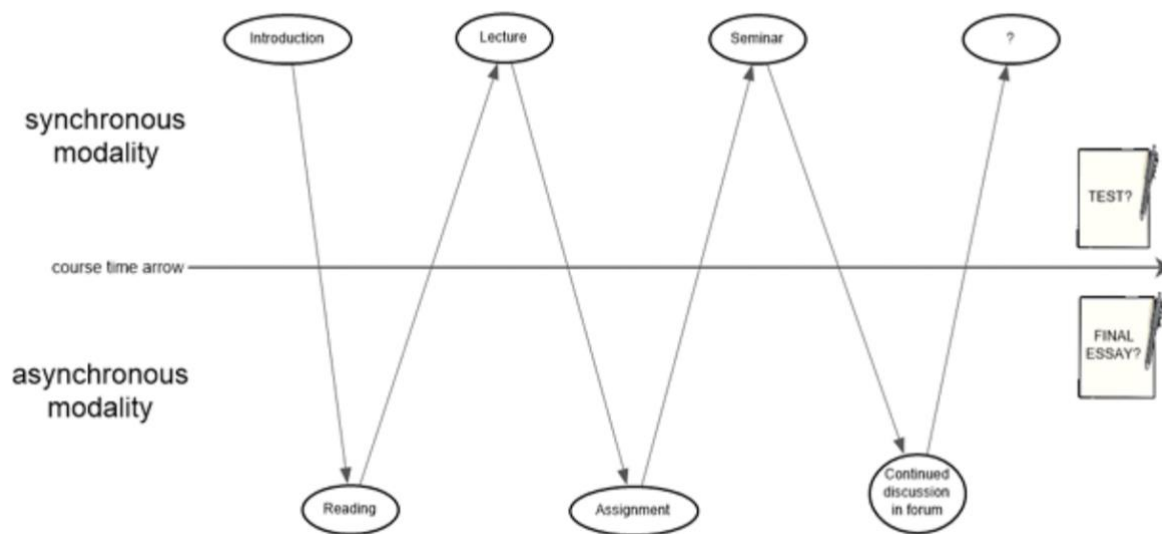


Figure 9 The synchronous-asynchronous shift pattern in a blended course

The most essential feature to think about when designing teaching for a course is to adapt the course design to the actual students and the learning objectives for optimising the progression of learning.

Students can be geographically dispersed and have many obstacles when attending classrooms and workshops for other reasons, such as part-time work or care of family members. Today, by a good blend, we can optimise both access to teaching and flexibility to study. Another objective is, of course, to make the course more resource efficient. Observe, however, that personal care of students and their learning situation and progression is essential, independent of which technology is used, and that digital technology as such has not been proven to be any magical solution for student learning.

6.3 THE ROLE OF THE TEACHER IN BLENDED LEARNING

Compared to the teacher's role in asynchronous online courses, like MOOCs, the teacher's role is central to the blended learning process. When the students have synchronous teaching at physical or online meetings, the participants can ask the teacher questions and the teacher can assess progress and adjust the teaching. The teacher can then provide personal guidance, feedback, and explanations for what the students have done in their self-learning parts. Teachers can thereby also discover the individual's commitment, opportunities, and difficulties differently during physical meetings than in digital ones. The students also have the opportunity to network and socialise with other course participants on these occasions, which is also an important part of pedagogical development work.

The teacher's attitude towards the students and towards her/his own role is an important factor to consider. Some teachers may focus their mission on sorting out the "good" students from the "bad" students, explaining varying learning success and preparing for setting grades. Other teachers are very focused and critical towards their own role as the explanation for students' varying success. (If I only had made this different...). Self-reflection and evaluation are good, but the teacher's behaviour is not the only explanation for varying learning success. The teacher should instead³¹ focus on maximising the students' activity: What are the students doing? Are the students doing the right thing to learn? Are the students using their time well? Are there any particular learning obstacles that can be removed to achieve better results for the group and the individual? The students are responsible for their role as learners – as teachers are for planning their teaching to enable students to learn.

The role of the teacher in blended learning is essential to create and maintain a sense of belonging, commitment and motivation for the students. The teacher also needs to be aware of how to adapt their active learning methods to the online environment and how to provide clear instructions and structure. There are many possibilities when teachers work with blended learning, but it also requires the teacher to switch between different roles, for example, guiding, supporting and guiding, depending on the situation and the student's needs. If one succeeds with these components, the teacher can also use the opportunities that digital technology offers to make teaching more educational, interactive and varied.

Planning strategy advice based on the time-based blended learning model:

Based on the learning objectives – some questions to reflect on in order to plan or design a course:

- ◆ What learning activities do we need in the course? (Introduction lecture/lesson? Readings? Assignment x, y? Workshop? Lab session? Discussion seminar? Group work? Problem-solving? Mini-project?)
- ◆ What are the learning progression demands? (Does X have to be learned before Y, etc.?)
- ◆ Which of these course activities must be synchronous in real-time?
- ◆ Which of these synchronous course activities must also be co-located (classroom, labs), and which must not (can be done with synchronous online sessions)?
- ◆ What can be done asynchronously and flexibly? (typically student assignments, readings, autonomous tasks, etc.)
- ◆ What time frames do we set up for the parts of the expected student's asynchronous work? (before a submission deadline or the next synchronous session, before the end of the course, etc.)

³¹ According to a model called Constructive Alignment, see Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher education*, 32(3), 347-364, available at https://teaching.helsinki.fi/system/files/inline-files/Biggs1996_Article_EnhancingTeachingThroughConstr.pdf. See also the three illustrative (and funny) Youtube films (19 min) «Teaching Teaching and Understanding Understanding». <https://youtu.be/iMZA80XpP6Y?si=YRrM3mzGaA4fXpOm> (Both resources accessed 12-03-2024).

- ◆ How can the chosen synchronous events be shifted with asynchronous events or tasks in the best way to support an even workflow for the students and avoid procrastination? (How will the shift between synchronous and asynchronous modes be constructed? An asynchronous task must be followed up on in the next synchronous session, etc.)
- ◆ Which students do we have, and what are their needs for flexibility and individualisation?
- ◆ How do we construct, stimulate and support the learning interaction between students?
- ◆ How do we construct the interaction between teachers and students? (For example, can we avoid unnecessary duplication in answering emails from individual students, etc.)

Please pay attention to

- a) **Time usage:** What the student does. Is he or she doing the right thing to learn, is time used well, and is enough time used?
- b) **The shifts** between synchronous and asynchronous elements of the course. For example, to make clear that an asynchronous student assignment or reading must be ready before the next synchronous meeting so that students' problems can be addressed, and the course can progress. Do not "tell" the contents of the assignments or readings to the students as if they are not supposed to do their asynchronous homework – answer questions instead and proceed – they will learn the routines.

Avoid these two traps when planning a Blended Learning Course:

1. **The two parallel courses trap:** When designing blended learning, watch out so it does not become two parallel courses with little overlap, one traditional classroom course (synchronous) plus an online asynchronous course. The synchronous elements should support and interact with the asynchronous work of the students and the other way around.
2. **The "course-and-a-half" trap.** It is very easy to expect too much asynchronous work and just fill a digital learning platform with all possible texts, assignments, links, etc. It can become too much content and make it hard for the student to prioritise. Research shows that it is important to be aware of the "cognitive load" that the use of digital resources can bring.³²

6.4 MODELS OF BLENDED LEARNING

The Flipped Classroom model

The “flipped classroom” is a model that means that students get access to the teaching material, for example, video lectures, texts, or podcasts, which they are expected to work with before they come to the lesson in the classroom or on an online platform. In this way, the teacher can use the lesson time to give more individual feedback, delve deeper into the subject, discuss questions and solve problems together with the students. The flipped classroom has several advantages, including the fact that students can work at their own pace, rehearse what they need, and choose the format that suits them best, but they need to be able to take more responsibility for their own learning. Flipped classrooms can also increase student motivation, engagement and collaboration.

³² Bradford, G. R. (2011). A relationship study of student satisfaction with learning online and cognitive load: Initial results. *The Internet and Higher Education*, 14(4), 217-226. Available at http://www.my-ecoach.com/online/resources/12228/All_docs12.pdf (Last access 12-03-2024).

The flipped classroom also has some challenges, such as requiring more preparation from the teacher, difficulty getting students to do homework, and technical issues, as some students are not tech-savvy and may lack interest in working digitally. A flipped classroom does not suit all subjects, situations, or students equally well. Therefore, the teacher must adapt the method according to his goals, conditions, and student group. This pedagogical model is an example of how the teacher can free up more time for what really makes a difference in learning, namely, the interaction between teacher and students.

The Rotation model

The rotation model³³ is useful, especially in courses with practical skills components. It is most often co-located and synchronous. The student, or a smaller group of students, can follow a schedule to rotate between learning stations with different instrumentation and design. Stations can be working with an online simulation, a lab task, a practical task (guided by a teacher or not), watching some video and working with follow-up questions, making instructions for a technical task, etc. There are many possibilities, but stations need to be prepared and designed. This rotation model can give the teacher time to interact with individuals or small groups while other students manage themselves. One drawback can, of course, be that some students need frequent help with stand-alone digital activities. If so, it can help with scaling up more students and more stations, assisted by more teachers than just one.

The À la carte model

In a à la carte model, students can choose rather freely between activities relevant to the course and, to some extent, also choose the order of learning activities and check them off. This may only suit some course content of a "hubs-and-spoke" kind where it does not matter much in what corner of the learning content (which wheel "spoke") a student starts. The student will eventually arrive at the "hub" (the ultimate learning objective) anyway. This model is less suited for linear progression content, where the student must master A to begin working with B, etc.

The HyFlex model

A HyFlex model³⁴ of blended learning is best suited for lecture-based theoretical courses with many students. It is a "hybrid" model, parallel school-based and flexible learning in the same package. All classroom lectures are recorded in real-time (often automatically, with so-called "lecture capture" solutions – recordings start in room X according to the course schedule for later asynchronous viewing – and are broadcasted synchronously at the same time). Students can choose to attend the lectures co-located, just synchronously (not in the classroom) or asynchronously (online, flexible) – or in a combination of attendance and later viewing, etc. An often-discussed risk with the Hy-Flex model is that students could become lazy and stay at home instead of attending lectures. This seems not to be the case as much as envisaged – many students like to attend lectures and interact with other students if they can. Students living far away, students working part-time, or those with children at home appreciate the flexibility. A drawback is the cost of a lecture-capture infrastructure.

³³ For the Rotation model and À la carte model, see p 26f in Christensen, C. M., Horn, M. B., & Staker, H. (2013). *Is K-12 Blended Learning Disruptive? An Introduction to the Theory of Hybrids*. Clayton Christensen Institute for Disruptive Innovation. Available at <https://files.eric.ed.gov/fulltext/ED566878.pdf>. (Last access 12-03-2024).

³⁴ See [7 Things You Should Know About the HyFlex Course Model \(educause.edu\)](https://www.education.com/learning/technology/hyflex) (Last access 12-03-2024).

The Wrap model

The Wrapped Course model³⁵ is especially suited to situations where the teaching institution does not have full competence to teach a course on, e.g., new technology or when only a very few students want to learn a piece of content. A wrapped course can be in a formal setting or, most often, in an informal setting. The model is also useful for train-the-trainers learning new content in a social setting. It may work like this:

- ◆ A good MOOC course from another school or another asynchronous web-based course is chosen as a central part of a local course led by a teacher.
- ◆ The study in the MOOC course is combined with weekly local problem-solving discussions, workshops, labs, and final examinations.
- ◆ The MOOC course can be a major part of the local course or just one component.

This model may be possible only in some education systems due to funding rules and only if the content of the MOOC course fits nicely into a local /national course.

Train-the-trainers' solutions are more flexible, and studying a MOOC course together with colleagues can be very stimulating and cost-effective for the school. This "wrapping" model has been in use for some years here and there at universities and vocational institutions, but there are no conventions yet on this kind of use of MOOC courses. Communication with the MOOC platform is advisable, especially if the course is studied free of charge online, but the local school charges tuition fees or saves resources by using this model.

6.5 ADVANTAGES AND DISADVANTAGES OF BLENDED LEARNING

There is no one-size-fits-all teaching method. Below is a summary of some advantages and disadvantages of blended learning. By combining the best of both worlds, blended learning aims to offer a more inclusive, flexible, engaging, and adaptable learning experience. Let's start by exploring the benefits.

Advantages of blended learning

1. Flexibility: Students can adapt their learning to their own pace and timetable but under the teacher's continuous help. They can supplement traditional classroom instruction with online materials and exercises when it suits them best.

2. Individualisation: Blended learning enables a more individualised learning experience. Students can choose materials and resources that suit their learning styles and needs. They can also go back and rehearse material they have difficulty with.

3. Increased accessibility: As learning materials are available online, students can access them from different locations and devices, increasing accessibility and convenience.

4. Engagement and motivation: The interactive and varied nature of blended learning can increase student engagement and motivation. The use of digital resources and interactive tools can make learning more interesting and engaging for some students.

5. Opportunity for self-management: Students develop self-management skills and responsibility when they have to organise their own learning and time management.

³⁵ See Bruff, D. O., Fisher, D. H., McEwen, K. E., & Smith, B. E. (2013). Wrapping a MOOC: Student perceptions of an experiment in blended learning. *Journal of Online Learning and Teaching*, 9(2), 187, available at https://www.academia.edu/download/34095325/bruff_0613.pdf. (Last access 12-03-2024).

6. Timesaving: Teachers can use classroom time more efficiently by focusing on discussions, questions, practical teaching elements and exercises rather than delivering long lectures. This can save time and provide more space for deep learning.

7. Increased interaction: Blended learning can promote interaction between students and teachers. Through digital tools, students can discuss topics, collaborate in groups and receive feedback. Through blended learning, the opportunities for interaction are expanded so that this does not only take place in a classroom environment.

8. Better access to resources: Online platforms give students access to a wider range of resources, including video lessons, web-based exercises and interactive simulations that can enrich learning.

9. Student empowerment: Blended learning also gives students the opportunity to develop their skills in searching, analysing, critically reviewing and presenting information from different sources. Blended learning is a way to promote lifelong learning in an increasingly digitised world.

9. Flexible Assessment: Teachers can extend their assessment by using digital tools to assess student performance and provide quick feedback.

Disadvantages of blended learning

1. Technical issues: Use of digital technology may lead to technical issues, such as internet outages and compatibility issues with devices and software.

2. Self-discipline: Students have more freedom to organise their own learning in blended learning environments; self-discipline and responsibility are required. Some students may find it difficult to manage their time and stay motivated without a structured classroom experience.

3. Digital divide: Not all students have access to a reliable internet connection and adequate technology at home, including a good learning space. This can create a digital divide where some students find it difficult to participate fully in educational activities.

4. Social Isolation: As part of the learning takes place online, this often leads to less physical interaction and social cohesion among students.

6. Training of teachers: Teachers who are not familiar with digital tools and methods may need training and support to implement blended learning effectively. This can be a challenge in many schools and educational institutions. Finding useful digital platforms that maintain good quality based on the course's goals and learning outcomes can also be difficult and time-consuming.

Blended learning is not just a trend but a necessary continuous development in any modern education system. It has become a new normality and is developing further. The blended learning of yesterday is just plain learning today when we go on to integrate new tools and models.

7 HOW? Different types of learners and their needs

Humans have different previous learning experiences and preferences on how to learn. Our learning processes are influenced by many different factors, depending on where we come from, previous school background, study techniques, experiences, learning preferences, and pedagogical methods. Family situation, place of living and other time or place obstacles add to these varying learning conditions. In the new green battery industry, new knowledge is required, which needs to be taught in different ways to many different people with different backgrounds and cultures, study habits, learning cultures and nationalities, which can be challenging from many different perspectives. An example of this could be the students' foreign language backgrounds and study backgrounds. This often requires a very adaptable and differentiated approach to education, learning, and continuing education.

Many educators still talk about students' different "learning styles". There are about 40 different models of "learning styles" in the literature. This has been shown to have almost no empirical support at all, so it is not evidence-based but rather a myth^{36 37}. All we can say is that students have various learning preferences. Furthermore, if learning styles were a thing, we could not do much with that – it is unrealistic to have many classes for different sorts of learners. However, learners' preferences can be satisfied by allowing students to use different media and study strategies. But this will be the case anyway in the rich information society – the problem is mostly critical thinking.

The new green battery industry today meets people from all over the world in various ways, and they need to be educated or further trained in the emerging green industry. This creates significant challenges from a learning perspective, and as a teacher, you need to think new, more innovatively, and creatively to ensure these individuals' skills and competence.

In this summary text, we have compiled some essential aspects to consider when teaching different groups and people from different cultures.

7.1 YOUTH LEARNERS

For young people, school is a central platform for knowledge acquisition, where structured curricula and pedagogical methods shape their intellectual and social development. Young people tend to benefit from interaction with their peers, and their learning is often focused on building foundational knowledge and skills for the future.

To create a conducive learning environment, we must pay attention to and tackle the specific challenges that young people face in today's complex society. A fundamental aspect of young people's learning involves meeting their needs in a meaningful way. This means that the teaching must be relevant and have practical application. The link between theory and practice is essential to increase motivation and commitment. If the motivation is there, then it becomes natural to learn more. Arousing curiosity and making learning an exciting exploratory environment is essential when working with young people.

Different teaching methods are needed when working with young people, so a broad palette of different types of activities is needed. Interactive activities, project-based, practical learning, and technology integration enable differentiated instruction, supporting each individual's learning journey. Social interaction

³⁶ Kirschner, P. A. (2017). Stop propagating the learning styles myth. *Computers & Education*, 106, 166-171. Available at <https://leftychan.net/tech/src/1627217656435.pdf> (Last access 12-03-2024).

³⁷ Riener, C., & Willingham, D. (2010). The myth of learning styles. *Change: The magazine of higher learning*, 42(5), 32-35. Available at http://sites.psu.edu/wp-content/uploads/sites/10091/2012/03/Reiner-and-Willingham_2010.pdf (Last access 12-03-2024).

and cooperation also play a crucial role in young people's learning process. By promoting cooperation and communication, not only technical knowledge but also social and soft skills are strengthened, which are essential for their future success.

A significant advantage of using digital material and tools in teaching is that it prepares young people for further digitalisation in the future. In today's technologically driven society, it is increasingly essential for students to develop solid technological skills. By integrating digital platforms into teaching, students become familiar with different technologies and learn how to use them.

In summary, adolescent learning is a complex and dynamic process. By understanding and adapting to their unique needs and challenges, we can create an inclusive and supportive learning environment that equips them with the skills and knowledge they need to meet future challenges.

Digital skills for Youth learners

When it comes to digital competence, there are both challenges and many opportunities in teaching young students. They are not all alike. Digital developments are very fast, which can be a challenge for those who do not have digital skills or interest in this competence, which is essential to consider when teaching. There is a challenge that a digital divide can arise between those with access to and knowledge of both computers and the internet and those with an interest in the subject.

Schools and society must work to ensure that all young people have equal opportunities to develop their digital skills and benefit from the digital world's resources. Then, there is also a question of interest. One aspect that becomes important to take into account is how we motivate students who are not interested in digital competence and those who do not learn through digital tools. The question we need to ask ourselves is how we motivate students who do not find interest in digital tools and how we meet the students who do not prefer learning through digital methods.

At the same time, digital competence opens up a world of opportunities for young people. They have access to vast amounts of information, can participate in global conversations, and can create content at levels previously impossible. It also gives them the opportunity to develop creativity and problem-solving skills using various digital tools and platforms.

There are many advantages to digital competence, but there are also many challenges regarding both use and consolidating and quality-assuring lifelong learning. Many young people spend a lot of time on various digital devices today, which can affect their learning, concentration and learning in a negative way. Finding the balance is essential. Studies have shown that those who read and take notes on the computer instead of doing these with a pen remember and learn worse. This is something you, as a teacher, need to take into account when working with young people and using digital tools.

Digital tools must be used in a meaningful way to improve teaching. An important aspect is that digital learning methods may need more personal interaction and social dimension than traditional teaching. This can negatively affect the students' social and emotional development, which is also an essential aspect of the student's future.

Schools must adapt to these changes by integrating digital skills into the curriculum in a balanced way and ensuring that teachers have the necessary skills to guide and support students in their learning. By doing this, we can help young people successfully navigate the digital era and take advantage of the opportunities and challenges that the digital world offers.

English skills for youth learners

When it comes to young people's skills in the English language, teachers face several pedagogical challenges. One of the central issues is the varying language skills among the students. Many come to the classroom with different levels of English skills and also opportunities to learn a language. Conducting good teaching can be challenging from several perspectives.

Motivation plays a key role in language learning, and it is a constant challenge for teachers to create engaging and relevant lessons. The use of authentic materials, creative activities and projects can be effective strategies to arouse and sustain students' interest in English.

Assessments and feedback are complex tasks. Teachers must find the right balance to assess different skills and provide constructive feedback that supports the student's continued development. This includes a varied use of assessment methods to cover both written and oral skills.

Another challenge is to strengthen students' linguistic confidence, especially when it comes to oral communication. The creation of a supportive and inclusive learning environment thus becomes important to encourage students to actively use English and overcome any barriers.

Language learning requires practising many different elements, such as reading, writing, listening, and speaking, and pedagogical skills are required to achieve results. Some students may become silent during track language learning, unsure of the subject. This may be because they feel insecure with the teacher or in the classroom. The teacher's pedagogical skills are required to create a safe environment to promote language learning.

In order for a student to dare to show his vulnerability in the subject, he needs to feel safe in the group. There is also a risk that some students learn to mask their language difficulties. The pedagogue can use his fingertip sense to determine how much an individual student can be pushed to become active. Some students sometimes need to be able to work and show their knowledge in smaller contexts or groups. For others, digital AI solutions can be a good tool for communication.

The impact of technology on language learning is another challenge. The increasing use of digital devices and social media can affect both written and spoken language skills. Integrating technology in a meaningful way to support language learning while managing potential distractions requires a thoughtful approach.

7.2 ADULT LEARNERS

Adult learning has a different pedagogical dynamic, often driven by specific needs and goals. Many adults seek knowledge and learning that is connected to their professional lives, personal interests, and careers. When we train in the new battery sector, this may be a completely new area for some, while others are well acquainted with the old technology and have a specific basic competence through both studies and previous work experience. It can be challenging for the pedagogues to meet and find a suitable pedagogical strategy for their teaching when the level and the students have such different backgrounds, knowledge, and experience.

Teaching adults requires an awareness of their specific needs and circumstances. The positive thing is that as an educator, you can benefit from their previous life experience and work experience. These experiences can be an asset in teaching because you can relate to relevant situations from their life and work. The goals for the teaching need to be relevant to their lives and future work. This creates a good commitment on the part of the students. Adult students are more likely to invest time and energy in learning if they understand how it can be applied practically, so blended learning also becomes a good way to meet students' different

learning needs. Adults also have different learning preferences, so it is beneficial to vary teaching activities, including presentations, discussions, group work, and practical exercises.

Fostering active participation is the key to successful adult education. By encouraging discussion and questions, you can create a dynamic learning environment where students actively participate in the process. Adjusting the tempo is also of great importance. Since adults have different paces in their learning, it is essential to be aware of this and adapt the teaching so that everyone can follow along. We need to respect that there are great individual and intellectual differences, even in adults, so the learning environment here needs to be inclusive and supportive, just as when teaching young people or those who come from other countries.

The link between theory and practice is essential for adult students. By showing in a purely practical way how things you teach can be applied in real life, motivation and commitment increase. This can be challenging if you work with a completely new technology or industry, such as the battery industry, so it can be nice to work with miniatures, innovations, and prototypes of various kinds in blended learning.

Providing constructive feedback and encouraging self-reflection is a method to promote learning. Adult students usually appreciate the opportunity to evaluate their own learning and identify areas for improvement.

Digital skills for adult learners

When teaching digital skills to adults, we find several differences from teaching young students. Teaching adults is challenging because they often have very different experiences of digital competence and interest. Some are almost beginners. Others have a great interest and are used to handling digital tools in several different areas. Teachers must adapt instruction individually to meet diverse abilities to create a meaningful learning experience. The motivation of adult learners is often linked to their specific needs and goals, especially related to their work or personal interests. Therefore, it becomes essential to integrate digital skills in a way that directly applies to their everyday challenges and goals to maintain motivation.

Previously used ways of learning and respect for individual experiences are also essential factors to consider. Adapting teaching to include different methods and allowing room for self-directed learning enables a more flexible learning environment. To overcome any uncertainty or fear of new technology, it is necessary to create a supportive and inclusive learning environment where adult learners feel comfortable exploring and asking questions.

Flexible learning times are also becoming important, given that many adult students balance work and family obligations. Offering options such as online courses or distance learning allows for a customizable teaching approach that considers their busy life schedules.

Applications of digital skills are central to adult learners, who are often more interested in concrete and real-life scenarios. Integrating these examples into teaching provides a direct link between theory and practice and thus increases engagement.

English skills for adult learners

Teaching English to adults is different from teaching young people. When teaching adults a language such as English, their previous schooling background and experiences with the language can be very different. Some have not been to school for many years, while others have just left school, and this becomes a challenge in terms of how to teach. Rehearsing different study techniques to enable the best learning process for

everyone is important here. It also requires good planning by the teachers and their materials in order to meet everyone's needs.

Learning preferences can be very different, and it can also be very challenging for a teacher when you meet people of many different ages with different school backgrounds and life experiences.

Adults' learning preferences are multifaceted and vary significantly from person to person. When considering adult learning, it is important to understand and adapt teaching methods to meet different learning needs. A central aspect of adult learning is awareness of the different learning preferences.

Using varying pedagogical activities in language teaching is central to being able to accommodate written and oral communication as well as anal writing. Some adults may prefer to take in

information through visual media, such as charts or presentations. Others learn through discussions and oral exercises, while another group is more comfortable reading and writing to learn a rhyme. Therefore, written material, books and notes can be an important part of language learning and to achieve lifelong learning.

Practical exercises and social learning are also important components, where cooperation, group work, discussions and interaction with other adults can be key to learning. These can be good when practising verbal presentation.

Self-directed learning is also an important aspect for adults. Many adults are taking the initiative to direct their own learning through self-study, online courses and self-reflection. This requires flexibility from educators and learning materials that enable and support self-management.

In the larger perspective of adult learning, it becomes crucial to recognize and respect the diversity of learning preferences that adults may have. Adapting instruction to include versatile learning materials becomes essential to maximize the understanding and success of adult learners in different learning contexts.

"I've come up with a set of rules that describe our reactions to technologies:

1. Anything that is in the world when you're born is normal and ordinary and is just a natural part of the way the world works.

2. Anything that's invented between when you're fifteen and thirty-five is new, exciting, and revolutionary and you can probably get a career in it.

3. Anything invented after you're thirty-five is against the natural order of things."

— Douglas Adams, *The Salmon of Doubt*, 2002

7.3 IMMIGRANT LEARNERS

For immigrants, learning is often linked to adaptation to a new culture and society. Language learning is a central part of their integration process and learning. Cultural differences and understanding of the local context also become part of their learning.

Immigrants face many challenges when learning in a new culture, a new language, and even a new subject of education. Language learning is often a priority and a necessity to facilitate communication and integration. Without language, it will also be much more challenging to be able to acquire the skills they seek and demand in education itself.

In addition to language, the understanding of cultural differences and societal norms are essential components of the learning process for immigrants. Many times, it involves informal learning through

interaction with local people and adaptation to new norms and values. Immigrants can benefit from specific educational programs and resources that help them navigate the complex aspects of their unique life situations.

Immigrants are a heterogeneous group who often bring with them knowledge and experiences from their country of origin that can be an asset in learning, but they can also have knowledge gaps, different study backgrounds, and even a lack of schooling, which makes this group challenging to teach. Many of these have never been in contact with digital technologies, so working with digitalisation and technology can be very challenging and cause them to lose their motivation and commitment when it becomes too complex and difficult to understand. These are essential factors to take into account; even if there are those with a good study background, one must not forget that the difference can be enormous in this group among those students.

Immigrants, above all, need to learn a new language or the working language but also adapt to contemporary society and culture. This means that they may need extra support and adaptations in teaching, as well as information about their rights and obligations as citizens.

Teaching immigrants is a complex task that requires a careful and culturally sensitive approach. A central focus should be on developing their language skills, both verbal and written, to facilitate communication and integration. At the same time, it is essential to build understanding and respect for different cultures in order to create an inclusive learning environment.

The connection between teaching and everyday life is also very important. By relating the learning to practical situations and everyday situations, the teaching becomes more relevant and motivating for immigrants, making it easier for them to apply their new knowledge in practice. Another aspect is that many who come from other countries may experience stress and several different forms of emotional challenges that should not be overlooked, as it may affect their learning. This is an aspect to keep in mind when meeting students from other countries because they have so many more parameters that can influence their learning than a student or adult student who often knows the language and society's norms and functions.

Digital skills for immigrants

Teaching digital skills to immigrants is a complex adjustment process where teachers face unique challenges and opportunities. A central challenge is the access to technology and resources, where immigrants may face extra difficulties depending on economic circumstances and adapting to a new culture. This requires flexibility and good strategies to ensure that all students have access to the necessary tools for digital learning.

Linguistic and cultural differences also present a significant challenge, with teachers having to be aware of how these factors affect students' understanding of digital instructions and tools. Adapted teaching then becomes the key to overcoming these barriers and creating an inclusive learning environment. The difference in previous experience in digital skills can be huge. Some immigrants have never seen a computer and may only have difficulty logging on to a computer, while others may have long and solid competence in digital skills, which makes it pedagogically challenging to be able to meet all students at their level. If possible, a level grouping would be good.

On the other hand, teaching digital skills to immigrants also offers unique opportunities. Cultural diversity in the classroom can create many great discussions that can give them knowledge about different perspectives on digital technology. This can create a dynamic learning environment where students learn from each other's experiences and enrich their own knowledge.

Flexible learning methods allow adaptation to meet different needs and learning styles, which is crucial for immigrants. Depending on what you work with, learning can also take place by learning from each other. However, the important thing is to adapt the learning to the immigrants' previous experience and to provide them with opportunities for learning as much as possible. This makes teaching more meaningful and relevant for each student and promotes a positive attitude towards digital skills.

Awareness of the immigrants' individual needs and a flexible teaching methodology are fundamental to creating an inclusive and successful learning experience for all students.

English skills for immigrants

Teaching immigrants English can be a challenging learning process that requires a sensitive and adaptable pedagogical approach. The essence of teaching lies in understanding and taking into account the unique needs and circumstances that immigrants face. A fundamental building block is cultural awareness, where teachers need to create an inclusive environment that respects and takes into account the diversity of cultural backgrounds in the classroom.

Individualized teaching is the key, given that the immigrants come with different levels of English skills. By adapting the teaching, teachers can offer extra support for beginners and, at the same time, challenge more advanced students. Focusing on practical and everyday subjects makes learning more meaningful, increasing engagement and motivation.

Using multilingualism as an asset in the classroom can be enriching. Encouraging the use of immigrants' first language and integrating it into learning can facilitate understanding and communication.

Flexibility in teaching methods is crucial to meet different learning styles and conditions among immigrants. Furthermore, the connection to society, its laws, norms, systems, and rules are important areas to facilitate integration and independence. Teachers can create learning around these areas and thus teach them several things at once that can be connected to their lives in the new country. This is something that can be done in all subjects, but in language learning, it is central because language is the key competence for the immigrant to be able to interact in society.

It is important to connect language learning to everyday life because immigrants face many more challenges when they come to a new country and have to integrate.

One difficulty is that the pedagogues need to find the "key" via different paths and understand how many times they need to explain, what needs to be explained and in what way it should be explained so that it becomes comprehensible to everyone. If the pedagogues find ways of working that can dissolve these linguistic blockages in the students, it can feel like all the pieces fall into place.

Some concrete tips can be that the students get help activating prior knowledge, practising strategies for tackling a text, working with words and discussing them, and working with how the words should be used. Go from the concrete to the abstract and back again.

Too few adult immigrants ask when they do not understand, perhaps precisely because it is difficult to express what it is that they do not understand or because they do not want to show it in front of the class. Therefore, it is of great importance that the pedagogue has different checkpoints in the different parts of the teaching to ensure that everyone is involved in the learning process and that the students feel safe both in the group and together with the pedagogue.

8 HOW? Use of OER and CC licenses

OER, Open Educational Resources are freely available content resources for teaching and learning. Most are Internet-based and build on the digital precise duplication possibility without quality loss and direct cost for duplication. Another older term is “digital learning objects”.

It is always necessary to reference the creator of the material, depending on the type of licensing, and balance what can be done with or without special permission. There are also commercial and educational resources, but the following focus is on openly accessible materials.

OERs always have creators who have made materials available and also often maintain and support them. In an earlier stage, a common understanding was that a course could be built by finding and combining such content objects as building blocks, a LEGO construction resulting in an Internet-based course. It soon became clear that this process was not that easy, as education is not a content-provision-only process. Content is a part of teaching and learning, but not all that is needed for education. The Internet only decreases the friction of information when making content available.

8.1 LEGAL ISSUES

Not all digital learning resources are free or easy to use, although they are easy to copy and distribute. Learning resources for a student, besides tuition, were once just items such as books and personal lab equipment, calculators, and so on. In our increasingly digital age, there are many commercially produced digital resources and digital resources that are bonus resources and come with owning a physical coursebook as an example. These resources are usually offered under conventional copyright, meaning that they can't be used outside the conditions specified. Such conditions of *fair use* vary in several ways: the purpose, context and volume of use of a copyrighted resource, how many people can access the resource, for how long, and the market effect on the original work. Internet-based content distribution has made it riskier to use copyrighted material illegally compared to use in a classroom (which was also not legal in many cases).

The actual facts from a copyrighted work are not copyrighted, but the way of expressing them can be. A common practice for using copyrighted videos (as a commercial movie) is that 15 seconds can be used as a referenced citation, but only if the video snippet is contextualised, commented or analysed, not just presented as-is.

When this sharing of educational material began to happen and be observed, in about 2000-2005, there were many makeshift models for allowing or limiting the use of learning material. This developed into a couple of new licensing models for OER, as for other digital works. The most used of these is the Creative Commons license³⁸, which has a national legal definition in most nations and easy-to-use standard sets of conditions to mark how educational material can be used. For example, it is possible to search on google.com (Google advanced search) by applying a Creative Commons filter. When searching keywords, the user will only find material that is usable on a specific license level. There are four symbols or license elements in CC that can be combined into sets to describe attribution demands, derivative works possibilities, commercial limitations, and the share-alike demand.³⁹

³⁸ <https://creativecommons.org/>

³⁹ <https://creativecommons.org/licenses/>



Figure 1 Example of Creative Commons symbol components⁴⁰

CC BY

This license allows others to distribute, remix, adapt, and build upon existing work, even commercially, as long as they credit you for the original creation. This is the most accommodating of licenses offered and recommended for maximum dissemination and use of licensed materials.

CC BY-SA (SA ... ShareAlike)

This license lets others remix, adapt, and build upon existing work, even for commercial purposes, as long as they credit the author and license their new creations under identical terms. This license can be compared to “copyleft” free and open-source software licenses. All new works based on this work will carry the same license, so any derivatives will also allow commercial use. Wikipedia uses this licence, and it is recommended for materials that would benefit from incorporating content from Wikipedia and similarly licensed projects.

CC BY-ND (ND ... No-Derivs)

This license lets others reuse work for any purpose, including commercial ones. However, it cannot be shared with others in adapted form, and credit must be provided to the originator.

CC BY-NC (NC ... Non-Commercial)

This license lets others remix, adapt, and build upon existing work non-commercially, and although their new works must also acknowledge the originator and be non-commercial, they don't have to license their derivative works on the same terms.

CC BY-NC-SA (NC-SA ... NonCommercial-ShareAlike)

This license lets others remix, adapt, and build upon existing work non-commercially as long as they credit the author and license their new creations under identical terms.

CC BY-NC-ND (NC-ND ... NonCommercial-NoDerivs)

This license is the most restrictive of the six main licenses, only allowing others to download the work and share it with others as long as they credit the creator and they are not changed in any way (NoDerivs) or used commercially.

⁴⁰ Image source: <https://jorg.pareigis.se/2/2019/02/10/anatomy-of-a-creative-commons-license/>

Another framework for the modern sharing of digital objects and code is the GNU (also called the GPL) license, created for open-source software code. It is run by the Free Software Foundation and is now in its version 3.^{41 42}

In the ALBATTs project, the basic CC BY-SA license, which fits most needs, was used.

8.2 USEFULNESS ISSUES

There are more issues when a teacher searches for an OER to use than finding an OER corresponding to a keyword search. There are issues like

- ◆ **Accessibility of the OER** The European Accessibility Act⁴³, of which the EU Web accessibility directive⁴⁴ is a part, requires that all new web and app-based information be accessible to everyone by alternative information about images presented, machine-readable text for audio listening and subtitles to videos, and so on.
- ◆ **Quality issues** – all from factual correctness to pedagogic quality
- ◆ **Pedagogical/didactic** fit into a course at the right level of teaching
- ◆ **Language** - even if English is often OK for academic levels, it is not the same for adult education. Some material is designed for ease of translation.
- ◆ **Technical format issues** - if a file format fits into the LMS used and can run on student computers and common home or mobile bandwidths.
- ◆ **Learning time of the OER** – if a module fits into the course concerning reasonable learning time. There is an obvious risk for a cognitive overload of student capacity if the teacher presents too much digital material or does not differentiate clearly between what is central teaching material and what is instead reference material.
- ◆ **The granularity of the OER** – A large OER, for example, a whole course, is a good find if it exactly corresponds to what a teacher needs. This is seldom the case. The optimal granularity of an OER should often be smaller - one concept, one problem at a time. If the size is too small, it is, of course, very flexible to use, but also not so difficult to just produce and solve locally – and therefore not always worth the time to search for.
- ◆ **Adaptability of the OER** - The possibility of using only a part of a learning resource or adapting it in other ways for a better fit.
- ◆ **Learning analytics possibilities** - Is there any assessment component attached so the teacher can know if the material has been used or even mastered to a decent level? This also depends on the functionality of the LMS.
- ◆ **“Blending” issues for the OER** - How can this OER be integrated into a synchronous-asynchronous shift pattern in course design? Can it be ensured that the OER does not just become an extra asynchronous learning material?

⁴¹ <https://www.gnu.org/licenses/gpl-3.0.html>

⁴² A comparison of licences is to be found here
[https://www.diffen.com/difference/Creative Commons License vs GPL](https://www.diffen.com/difference/Creative+Commons+License+vs+GPL)

⁴³ <https://www.funka.com/en/design-for-all/accessibility/the-european-accessibility-act-is-published/>

⁴⁴ <https://ec.europa.eu/social/main.jsp?catId=1202>

9 HOW? Blend with AI - Large Language Models

Information and Communication Technologies, ICTs, have a particular interest in teaching and learning. They lower the friction of information.⁴⁵ Writing, print, postal mail, TV, radio, and telephone are some examples – and in our times, Internet-enabled media and communication have considerably lowered information friction. We have access to information as never before and can communicate in high resolution and in real-time over long distances.

However, the lowering of information friction by new ICTs has been going on for hundreds of years. What is radically new with digital technologies is their ability to also process information outside biological brains with algorithms, computer programs and robots.

In early 2023, a new AI technology, “Large Language Models” (LLMs), arrived before the public eye, astonishing some and frightening others^{46 47}. It lowers the friction of information by processing vast amounts of information and producing answers to questions. It seems that the need for classic Internet (and also non-Internet) searching may be reduced.

Whether this constitutes intelligence is a whole other question. We can say that LLMs answer questions by collating relevant information collected from different corners of the Internet. This functionality can indeed be used by teachers and by their students. It does not replace teaching or learning but can give more options for both these processes.

Let’s look closer at LLMs and their possible uses for teachers. Please notice that we are all at the very beginning of this development of LLMs, but the following will hopefully be informative and help you start thinking about how to use LLMs.

9.1 LARGE LANGUAGE MODELS – WHY, WHEN, HOW?

Large Language Models (LLM) or AI Learning Models are AI algorithms that use deep machine learning and vast amounts of data to understand, summarise, generate and predict new content.⁴⁸

An OECD article states:

*“AI language models are a key component of natural language processing (NLP), a field of artificial intelligence (AI) focused on enabling computers to understand and generate human language. Language models and other NLP approaches involve developing algorithms and models that can process, analyse and generate natural language text or speech trained on vast amounts of data using techniques ranging from rule-based approaches to statistical models and deep learning. The application of language models is diverse and includes text completion, language translation, chatbots, virtual assistants and speech recognition”.*⁴⁹

⁴⁵ «The amount of work required for an entity to access another's information», see Floridi, L. (2005). The ontological interpretation of informational privacy. *Ethics and information technology*, 7, 185-200. Available at <https://uhra.herts.ac.uk/bitstream/handle/2299/1820/901816.pdf?sequence=1&isAllowed=1> (Last access 12-03-2024).

⁴⁶ García-Peñalvo, F. J. (2023). The perception of Artificial Intelligence in educational contexts after the launch of ChatGPT: Disruption or Panic?. *Education in the Knowledge Society* 2024.

⁴⁷ <https://www.cnn.com/2023/11/30/chatgpts-one-year-anniversary-how-the-viral-ai-chatbot-has-changed.html> (Last access 17-03-2024)

⁴⁸ Sean Michael Kerner, Definition: large language models (LLMs), WhatIs.com, <https://www.techtarget.com/whatis/definition/large-language-model-LLM> (Last access 12-03-2024).

⁴⁹ OECD (2023): *AI language models: Technological, socio-economic and policy considerations* OECD Digital Economy Papers, No. 352, OECD Publishing, Paris, <https://doi.org/10.1787/13d38f92-en> (Last access 12-03-2024).

AI is already having an impact on education, and it will increase in the future. In the Oxford University Press report, 68 % of schoolteachers in the UK and 69 % of English language teachers in Europe see the benefits of using AI in education as positive but would approach it with caution.⁵⁰

The upcoming sections are dedicated to exploring generative AI models and their capabilities to analyse or generate text, based on users' interests and demands.

9.2 GENERAL GENERATIVE CHAT-TYPE AI MODELS

Learning materials produced within the ALBATTs project are a state-of-the-art snapshot of e-mobility battery technologies. But in the next few years, battery technology is going to continuously evolve further and will, on some occasions (especially just before teaching materials updates), exceed the knowledge captured in the teaching materials.

This why we prepared a short introduction to using generative AI models like ChatGPT (<https://chat.openai.com/>), Bing (<https://www.bing.com/>), Bard (<https://bard.google.com/chat>), etc., to stay in touch with the latest developments or get detailed clarification of different e-mobility batteries technology.

Image 1 shows a ChatGPT answer to the question, 'What are the newest e-mobility battery trends?'. Chat GPT version 3.5 covers background knowledge until January 2022.

If we are not happy with the answer, we can ask ChatGPT to regenerate the answer, make it shorter, elaborate on specific topics from the previous response, and so on (see Image 2).

⁵⁰ *AI in education: where we are and what happens next*, Oxford University Press, 18 October 2023, <https://corp.oup.com/feature/ai-in-education-where-we-are-and-what-happens-next> (Last access 12-03-2024).

MI

what are the newest e-mobility battery trends?



As of my last knowledge update in January 2022, I can provide some insights into the e-mobility battery trends that were emerging at that time. However, please note that the field of e-mobility is rapidly evolving, and there may have been significant developments and trends since then. Here are some trends that were relevant in early 2022:



1. **Solid-State Batteries:** Solid-state batteries were a hot topic in the e-mobility industry. They promised several advantages, including higher energy density, faster charging, and enhanced safety. Companies like Toyota and QuantumScape were at the forefront of developing solid-state battery technology.
2. **High-Nickel Cathodes:** Battery manufacturers were increasingly shifting to high-nickel cathode chemistries because they offer higher energy density. This trend aimed to increase the driving range of electric vehicles (EVs) without significantly increasing the size and weight of the battery.
3. **Fast Charging:** Fast-charging technology was being improved to reduce charging times for EVs. Higher charging speeds were enabled by advancements in battery chemistry, thermal management systems, and charging infrastructure.
4. **Sustainability and Recycling:** Battery recycling and sustainability were gaining importance. With the growth of the EV market, ensuring the responsible disposal and recycling of batteries was becoming a priority. Companies were working on ways to recycle lithium-ion batteries more efficiently and recover valuable materials.
5. **Bifacial Solar Integration:** Some electric vehicles started to experiment with integrating solar panels into the vehicle's design. These panels could charge the vehicle's battery and increase its overall efficiency.
6. **Wireless Charging:** Wireless charging technology for EVs was under development. This technology aimed to make charging more convenient by eliminating the need for physical plugs and cables.
7. **Second-Life Batteries:** The concept of reusing batteries from electric vehicles in stationary energy storage applications was gaining traction. These "second-life" batteries could be used for energy storage in homes and businesses, extending their lifespan.
8. **Advanced Battery Management Systems (BMS):** BMS technology was improving to optimize the performance and longevity of EV batteries. Advanced BMS allowed for better monitoring, predictive maintenance, and thermal management.
9. **Graphene and Silicon Anodes:** Battery researchers were exploring the use of graphene and silicon anodes, which could increase energy density and improve the overall performance of lithium-ion batteries.
10. **Partnerships and Collaborations:** Automakers, battery manufacturers, and technology companies were forming partnerships to accelerate battery development and EV production.


Please keep in mind that developments in e-mobility and battery technology continue to evolve rapidly. I recommend checking the latest news, industry publications, and research papers to stay up-to-date with the most recent trends and innovations in the e-mobility battery sector.

Regenerate

Image 1 ChatGPT responding to the question, 'What are the newest e-mobility battery trends?'

Default (GPT-3.5)

MI please elaborate on solid state batteries

 Solid-state batteries represent a promising technology in the field of energy storage, including their application in electric vehicles and various electronic devices. They differ from traditional lithium-ion batteries in that they use solid electrolytes instead of liquid or gel electrolytes. Solid-state batteries offer several potential advantages, although they also come with their own set of challenges. Here's a more detailed look at solid-state batteries:

Components of Solid-State Batteries:

1. **Solid Electrolyte:** The most significant difference in solid-state batteries is the use of a solid electrolyte instead of a liquid one. This solid electrolyte serves as the medium for the transport of ions (typically lithium ions) between the anode and cathode. Solid electrolytes can be made from various materials, including ceramics, polymers, and composites.
2. **Cathode:** Similar to traditional lithium-ion batteries, solid-state batteries have a cathode, which is typically made of materials like lithium iron phosphate (LiFePO₄), lithium cobalt oxide (LiCoO₂), or other advanced materials with high energy densities.
3. **Anode:** The anode in solid-state batteries is usually made of materials like lithium metal or various forms of carbon, such as graphite.

Advantages of Solid-State Batteries:

1. **Safety:** Solid-state batteries are generally considered safer than traditional lithium-ion batteries because they are less prone to thermal runaway and the risk of fire or explosion. The solid electrolyte is stable and less susceptible to leakage or overheating.
2. **Energy Density:** Solid-state batteries have the potential for higher energy density, which means they can store more energy in a smaller and lighter package. This can lead to longer driving ranges in electric vehicles and longer-lasting electronic devices.
3. **Fast Charging:** Solid-state batteries are expected to support faster charging times due to their improved conductivity and reduced risk of overheating. Rapid charging without compromising battery life is a significant advantage.
4. **Longer Cycle Life:** Solid-state batteries may have longer cycle lives, which means they can undergo more charge-discharge cycles before their capacity significantly degrades.

Challenges and Limitations:

1. **Manufacturing Complexity:** Solid-state batteries are more challenging to manufact

 Regenerate

Send a message 

Free Research Preview. ChatGPT may produce inaccurate information about people, places, or facts. [ChatGPT September 25 Version](#)

Image 2 ChatGPT response on solid-state batteries.

Sometimes, looking for the “right” questions may be the hardest task. If we are not skilled in prompt engineering⁵¹, we can also use the response of the tool to see what other people were asking about similar topics and drill for further knowledge.

Here is an example from an ordinary search at [bing.com](https://www.bing.com) (see the ‘People also ask’ section on Image 3).

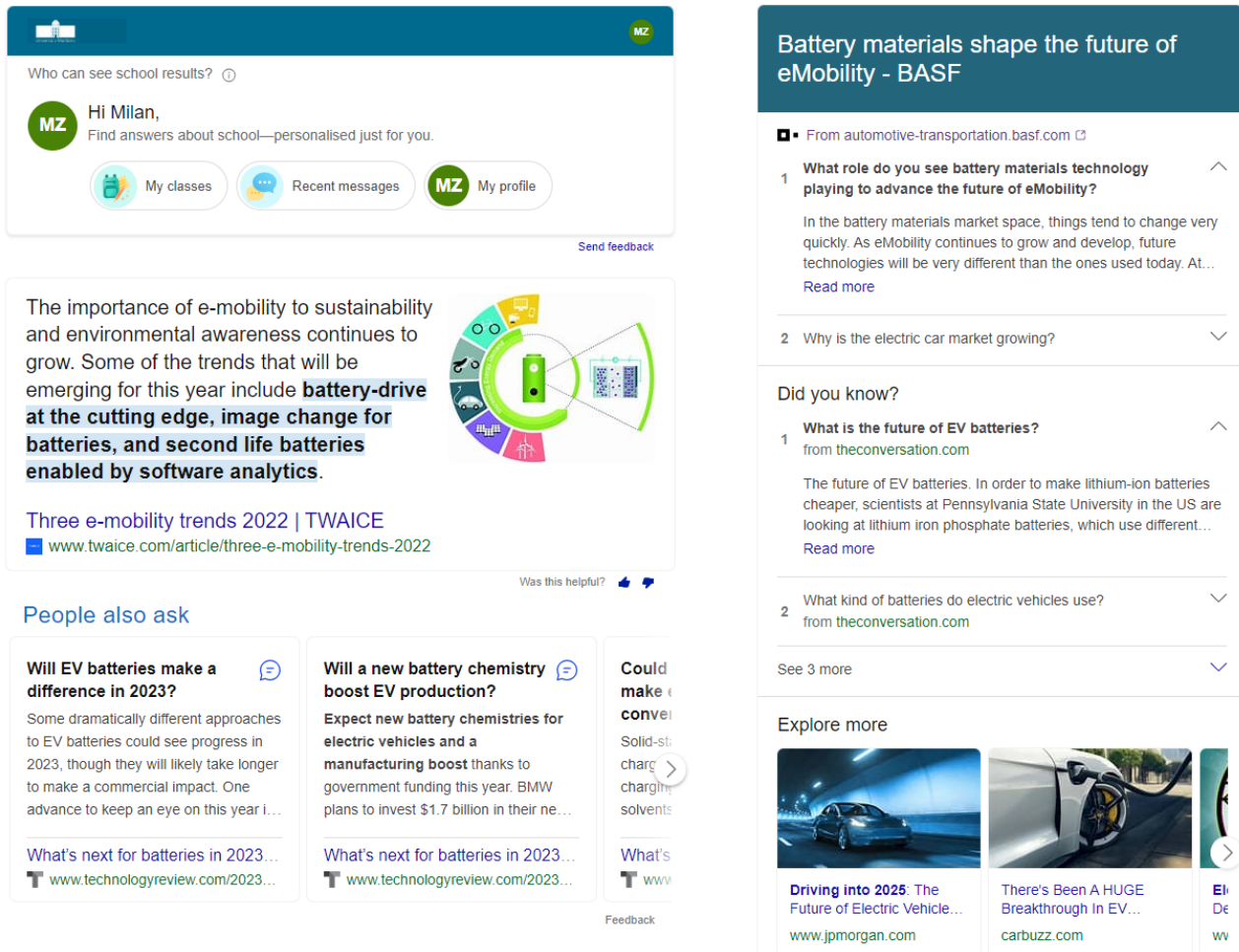


Image 3 Bing.com search responding to the question ‘What are the newest e-mobility battery trends?’

9.3 PROMPT ENGINEERING

As you can see, we have tried to keep our questions to the models short and crisp. Not knowing how to prepare questions effectively and efficiently to the LLMs often leads to unexpected behaviours of the model. Prompt engineering helps to reduce failure cases and computing costs when working with LLMs.⁵²

⁵¹ <https://www.techtarget.com/searchenterpriseai/definition/prompt-engineering> (Last access 12-03-2024).

⁵² Elvis Saravia, Prompt Engineering for LLMs, <https://maven.com/dair-ai/prompt-engineering-llms> (Last access 12-03-2024)

If we would like to get more elaborate responses from LLMs, we must apply prompt engineering techniques to design questions/requests to interact optimally with other inputs and help elicit better answers from the AI model.⁵³

9.4 'CHAT WITH DOCUMENTS' TOOLS

We have also tested a few document analysing tools, where you can upload your own document (PDF, doc, etc.) and the chat tool will analyse it and enable the user to ask questions on the topics covered in the document:

Askyourpdf (<https://askyourpdf.com/>)

Chatwithpdf (<https://chatwithpdf.ai/>)

Chatpdf (<https://www.chatpdf.com/>)

All three tools gave different, approximately correct, but far from good or perfect answers. All the required data and correct answers were scattered throughout the document and were also systematically summarised in the final part of the uploaded document.

Askyourpdf was the most telegraphic and had the least guessing. Still, it missed at least 50 % of the correct answers on two questions. Chatwithpdf was fishing for answers, and practically none were relevant. Chatpdf was a bit worse than Askyourpdf, but was able to display some deductive logic, which was interesting.

The problem we currently see is that 'chat with PDF' type tools may give a novice user false confidence that all the relevant data on the topic have been presented when the tool has been used. This may not be the case. Hopefully, these tools will evolve further in the near future.

9.5 WHAT MIGHT BE THE DRAWBACKS OF USING GENERATIVE AI?

LLMs learn continuously from new resources, such as customer questions and responses. That is why we might not get the same answers to the same questions after a certain period.

Critical thinking is still required: the GIGO (garbage-in-garbage-out) rule still stands in AI. If a lot of false input (deliberate or not) is given for a certain topic, then the AI knowledge may steer away from the correct answers.

Not knowing how to correctly articulate the question: Here, the GIGO rule is also applied – bad questions will most probably provide less-than-perfect responses. Educate yourself in Prompt Engineering and take full advantage of LLMs.

Be sure to double-check more sensitive information before using it. Some tools can provide underlying resources, and some cannot.⁵⁴

Reliable graphical representations like diagrams, plans, and exact images still cannot be generated and must be searched separately in the majority of chatbots (Bing can be an exception in some cases), so for instance, getting diagrams of solid-state batteries requires separate steps in ordinary search tools (see Image 4).

⁵³ McKinsey & Company, *What is prompt engineering?*, September 22, 2023, <https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-prompt-engineering> (Last access 30.11.2023).

⁵⁴ One example of a LLM that gives sources is [Perplexity](#). (Last access 12-03-2024).

MI

Please provide a diagram of Components of Solid-State Batteries



I'm sorry for any confusion, but I can't directly create or display images or diagrams.



However, I can describe the components of a solid-state battery, which you can use to create or search for a diagram on your own:

1. **Solid Electrolyte:** The central component of a solid-state battery is the solid electrolyte, often represented as a solid layer in the middle. This electrolyte allows the flow of ions (typically lithium ions) between the cathode and anode.
2. **Cathode:** One of the terminals of the battery is the cathode. It is typically a layer or material at one end of the solid-state battery and is responsible for receiving lithium ions during discharge.
3. **Anode:** The other terminal of the battery is the anode. This component is situated at the opposite end of the solid-state battery and is responsible for releasing lithium ions during discharge.
4. **Separator:** Although not a liquid separator as in traditional lithium-ion batteries, solid-state batteries may include a separator layer to prevent short circuits between the anode and cathode. This separator is a solid component within the battery structure.
5. **Current Collectors:** Solid-state batteries typically include current collectors on both the anode and cathode sides. These collectors help with the transfer of electrons between the battery and the external circuit.
6. **Encapsulation:** Solid-state batteries are often encapsulated to protect the components from environmental factors and to maintain their integrity. The encapsulation can be a solid casing or packaging that surrounds the battery.

You can use these descriptions to create a diagram of the components of a solid-state battery or search online for pre-existing diagrams to further illustrate the concept.

Image 4: ChatGPT response on asking for a diagram of solid-state batteries.

Examples of questions:

- ◆ What are the newest e-mobility battery trends?
- ◆ What safety precautions do we have to take with solid-state batteries?
- ◆ What is the role of an electrolyte in a battery?
- ◆ Which battery type is the best for home stationary applications?
- ◆ What is the best way to charge Lithium-Ion Batteries?
- ◆ What to do in the case of an e-bike fire?
- ◆ Compare Ni-MH and Li-ion batteries.

You can also try to when asking questions like these,

- To assign the LLM a role to apply when the question is answered: "Please answer me as an engineer", or "Please answer me on the level that a 10-year-old can understand", or "Answer me with a clear instruction on how to" or "Act as an instructional designer and give me an

interactive lesson plan to teach about battery safety in 60 minutes for vocational young students in a vehicle repair program?

- To begin with a conversation with the LLM, with the intent to give the LLM the best possibilities to deliver a high-quality answer. (This may not be possible with all applications). "I am interested in models for teaching about repairing and troubleshooting home batteries for vocational electrician students. Please ask me what you need to know from me to give me the best possible answer."

Concluding reflections on LLMs and learning

An LLM is like your talkative friend who never leaves your question unanswered. He talks, talks, and talks, and in that process, he uses an impressive amount of stored information. He seems also to be able to produce some fake information just because he is so willing to answer your question rather than be silent. It is also like getting directions on how to find your way to an address in a city unknown to you from a willing and helpful person on the street, concluding directions with "You can't miss it". What he says sounds very true at the moment, but it is hard to fact-check instantly. He can also change his mind very quickly when faced with doubt from your side. However, he wants to be helpful, and perhaps he is. You will know later when doing a reality check (finding your way).

A practical examination reflection: A considerable part of a traditional examination of student learning is asking the student to repeat points from the course literature. Another kind of evaluation is to give the student an essay assignment. Both these examination methods are soon to be historical, as it is so easy to find shortcuts with the help of LLMs. The student can pass but without much learning. We can hope that the evaluation of learned **skills** by demonstration can, in the future, increase in importance as an examination method. One such skill is to be able to ask relevant questions in connection to a situation or problem.

A final philosophical reflection: In all human learning, the right questions are more important than the "right" answers because the answers develop and change with time and situation, while questions often survive. This does not mean that all truths are relative, but that human knowledge constantly develops and adapts to new situations. Therefore, the art of asking the right questions in the optimal way to get the best answers is an important skill. It becomes extra obvious with the use of LLMs.

10 Summary and recommendations

The European industrial value chain of batteries is young, newly born, and still not fully organised and mature. At the same time, it is of utmost critical importance for reducing emissions, fighting global warming, and strengthening European competitiveness and the work market.

The ALBATTs project was developed parallel to the birth of this industrial sector of batteries, and it tried to watch and analyse what was happening, especially concerning job roles and skill needs. On this knowledge basis, we have worked on preparing help for European education and training providers in national education systems. We have developed learning objectives, curricula, learning materials, and recommendations for different levels of education and training systems. One additional task is to work with “training the trainers”. This handbook is a part of this latest task.

Developing and providing vocational education and training with hands-on experience and work-based learning in authentic environments is challenging in a still emerging (or even in places still non-existent) industry, such as the battery industry. The plants are still under construction and adjustment, during which time their prime focus lies in getting the production to run smoothly with newly hired staff. There seems to be little time for engineers and workers to care for teachers' study visits, internships, and apprenticeship students. In addition, plans for new factories are often delayed or postponed. It is difficult for VET schools and trainers to know whether to start up training, invest in learning environments and get their staff trained.

Our experience in the ALBATTs project shows that teachers from all over Europe seem to face the same challenges and have the same concerns regarding training for the battery industry. Many of these challenges will likely prevail until the industry becomes more mature. The battery value chain in Europe and its connected education and training needs will also continue to develop rapidly over time, and the ALBATTs project results can be seen as a starting point for departure into the future.

For enabling an optimal development of education and training, presented below are several recommendations outlined from the ALBATTs project in 2024:

For VET schools, professional education providers and their teachers, we recommend to

- ◆ Be proactive! No one will develop your education strategy and offerings - you most likely have to do that yourself.
- ◆ Form a close cooperation with the company or companies as early as possible – they may help with training content material, learning environments, internships for teachers and students, etc.
- ◆ Stay constantly in contact with the national and regional educational authorities and inform them of the needs of curricula development, cross-disciplinary perspectives, etc. This can also be done in cooperation with the companies. The national authorities will not know what changes are needed in the curricula if no one tells them.
- ◆ Cooperate with higher education establishments both on subject knowledge and possible learning environments. You can find many synergies in developing knowledge and skills, developing training material, learning environments and sharing costs.
- ◆ Study the ALBATTs job Skills Cards and upcoming job advertisements for the battery industry in parallel. It gives a picture of the job roles and the skills needed in the industry.

- ◆ Watch online webinars with many experts provided by the ALBATTs project <https://www.project-albatts.eu/en/listnewsevents> and the vast amount of YouTube clips on the industry available. In addition, you will find much information in the ALBATTs reports.
- ◆ Use the ALBATTs basic courses to learn the industry's basics. If you struggle with English, you can use English courses as support.
- ◆ To deepen your knowledge, study some MOOC courses or take part in more advanced courses. Form study circles among teachers in your school or within your networks. It becomes much easier and more fun to learn! All have previous relevant experiences to link to this new area of education and training, and discussing questions, problems, and possibilities with peers is interesting.
- ◆ Get involved and offer ERASMUS mobilities and internships (KA1) abroad for your teachers. This is a great way to acquire new knowledge and to network.
- ◆ Get involved in national and international development projects for VET schools for the battery industry, and get your teachers involved in these projects. It will develop their substance knowledge, digital skills, and English skills and enlarge their networks.
- ◆ Develop digital skills in your organisation to develop different learning environments using the latest technology.
- ◆ Explore and learn how AI can be utilised both regarding content development and learning environments.
- ◆ Incorporate training methods that also strengthen the students' soft skills, digital skills, English skills, and skills to be able to function in multicultural working environments.

For universities and university colleges, we recommend to:

- ◆ Review the programmes that are presently offered, especially engineering programs, to see how they can be adapted to the needs of the battery and electromobility sector and the wider green skills sector in your region or country. A first adaption can be offering optional orientation courses and exam work subjects, etc., adapted to future needs.
- ◆ Cooperate with universities that are actively researching batteries and electromobility if you do not presently have those disciplines represented at your university. Subcontract another university to run a needed course or two while local research, and thereby teaching competence, is built up.
- ◆ Use the possibility to “wrap” a relevant MOOC course on batteries. You can do seminars, labs, and examinations locally, but you must use the teaching and material from the MOOC course. Contact with the MOOC platform is recommended, as this is still a non-regulated area.
- ◆ Cooperate with relevant regional and national industries to discuss and access exam work opportunities and internships.
- ◆ Cooperate with regional industry and relevant VET schools concerning labs, pilot plant access, co-teaching possibilities and similar.

- ◆ Examine the possibilities for your country concerning access to EC-funded relevant research labs (EC recommends these to be open for education and training needs).
- ◆ Participate in relevant EC R&D projects and look also for the education development possibilities in such tasks. Check also up on opportunities to network and fund with ERASMUS+ calls and the Pact for Skills initiative.
- ◆ Discuss if your university should join Batteries Europe, Batteries European Partnership Association (BEPA), European Battery Association (EBA) or other EU-wide initiatives for research and education development on the European cooperation level.
- ◆ Be innovative and radical and speed up the development of needed education offerings! The present situation of urgently needed climate action demands an unconventional speed of decision-making, including in higher education.

For national and/or regional authorities, we recommend to:

- ◆ Develop more flexibility in the national curricula work and legislation to be agile and quickly answer the needs of the battery and electromobility industry.
- ◆ Create national incentives for cooperation between VET schools, between universities (as an exchange of course offerings), and between VET schools and universities.
- ◆ Develop a modular system where the modules and learning outcomes can quickly be changed and updated to respond to the needs of the industry. The smaller the modules are, the easier it is to update or change them.
- ◆ Develop possibilities for cross-disciplinary studies so that students can get insight into the process industry, electrical engineering, automation and robotics, mechanical engineering, digital skills, etc. In the battery industry, the need for skills is vast and reaches over different disciplines.
- ◆ Provide funding for teacher training, including the possibility of doing internships in the industry.
- ◆ Provide funding for the development of both physical and virtual learning environments.
- ◆ Provide funding mechanisms that encourage educational providers to work together and develop training content and virtual learning environments in a common way.
- ◆ Incorporate the development of key competencies for lifelong learning, soft skills, and digital and English skills in the curricula.
- ◆ Put the needs of the battery and electromobility value chain in the context of all needed green skills in the context of EC and global climate action.

For companies, we recommend to:

- ◆ Communicate and cooperate with the education providers and involve them in the early stage of a battery cell plant or related industry project.
- ◆ Help the training providers by providing authentic training material and content, learning project materials and similar.
- ◆ If the company has a pilot plant, digital twin, and/or training unit, let public education teachers take part in training and experience learning in a real environment.
- ◆ Offer teachers and more advanced students the possibility of on-site experience through company visits and internships.
- ◆ If needed, to let teachers into a plant with IPR issues, write a customised NDA (non-disclosure agreement) if necessary, rather than not letting teachers in.
- ◆ Coordinate the scope of available public education with your onboarding programmes for newly employed staff and your in-house training for the best total results.

For the European Commission, we recommend to:

- ◆ Encourage member state countries to adopt a flexible and modular curricula approach to meet the industry's rapid change.
- ◆ Encourage member state countries to broaden programs with the possibility of cross-disciplinary content.
- ◆ Promote cooperation between vocational education and academic education.
- ◆ Stimulate the speed of change concerning the development of new green education at universities by (as an example) incentivising universities to cooperate about course offerings.
- ◆ Make the development of education and training content a more important part of relevant research calls and grants in the sector.
- ◆ Provide funding for the development and investment in physical and virtual training labs.

For all stakeholders, we recommend acting quickly and wisely, as greening skills are critical for European and global climate action and, in the longer perspective, for human survival. The situation should motivate us to take more radical and innovative action to remediate the situation as best as possible.
