MOOC SUMMARY

MOOC Week 1: Introduction

THE **ELIC PROJECT** is financed by the Erasmus+ EU Programme Strategic Partnerships for Adult Education; ELIC is an acronym that stands for Engineering Literacy Teachers as Medium for Change.

This Project aims to provide a didactical toolbox for teachers to increase engineering skills among secondary school pupils. In order to achieve this goal a MOOC (Massive Open Online Course) has been specifically designed for teachers of STEM (science, technology, engineering and mathematics) subjects.
The **ELIC MOOC** is an open educational resource (OER) addressed to secondary school teachers of STEM subjects that should help them to develop an engineering mind set amongst pupils aged 15-18 and increase their interest in engineering professions. The MOOC consists of 6 modules and runs over a 6-week period. Examples and experiments taken from automotive engineering are linked to content from different STEM subjects to show how knowledge of natural and technical sciences can be applied to real-world engineering problems.

To better learn from this MOOC a Facilitator and a Moderator are available every week to answer the questions that come up among the teachers.

- The Facilitator is the person that provides learning materials, tasks and assignments (e-tivities) to the topics present in the MOOC.
- The Moderator is the person that monitors the online learning process and actively supports learners in case of need.

A platform to post comments and questions is available for every single MOOC lesson, to allow teachers to interact with each other and also with the Moderator.

The first module (Week 1) of the MOOC is an introduction to explain how and when the lessons are launched and gives an overview of the contents. It aims to give a general introduction to the MOOC methodology, structure and requirements to get used to this online learning space and to understand how the ELIC MOOC is structured.

The second module (Week 2) introduces participants to electric motors in general, system engineering, and shows how electric motors are used in cars.

The third module (Week 3) develops the contents of internal combustion engines and to the impact on society and environment, from various perspectives.
The fourth module (Week 4) gives an introduction on how modern headlamps and rear lamps are used in cars and provides a system engineering understanding which allows teachers to assign

experiments at school. Further, battery systems are explained in general, and how they are implemented into modern vehicles.

The fifth module (Week 5) focuses on “Hot Topics in Engineering” and discusses current issues in engineering, which include energy management, autonomous driving and cyber security.

The sixth module (Week 6) is the Recap week, where facilitators and moderators recap and summarize the highlight topics that have been discussed during the last five weeks. Further, learners have the chance to get the final certificate from the European Certification and Qualification Association, the ECQA.

MOOC Week 2: E-Motor

The course focusses on the most used e-motor concept in cars. It includes:

(1) Motivation for E-Motor Concepts

The course first gives an introduction to e-motor concepts and explains why different subjects (Physics, Chemistry, Mathematics, Biology, Ethics, Informatics, Language) are involved. The introduction also explains the major functional parts of an e-motor.

(2) System Engineering Picture/Understanding of an E-Motor (2 hours)

The course defines system engineering and explains how the e-motor works in detail. It also refers to a manual of TI (Texas Instruments) which contains further details of physics.
This includes a lecture about the systems engineering and again outlining in more details how the different subjects are involved.
It also includes here a lecture about physical background of e-motors for those who are interested in physics.

Additionally, there is a video showing a running e-motor and naming the parts visible in the video.

MOOC Week 3: Internal Combustion Engine

General Description of this module

The aim of this week is to give an introduction to the operation of internal combustion engines and to their impact on society and environment. The working process of the internal combustion engine is divided into 5 topics.

Overview / Engine Mechanics

A fundamental requirement for the engine is to be supplied with energy, which is chemically bound. It is made up of two essential components: carbon and hydrogen. For the combustion, oxygen is needed. During combustion, the carbon and oxygen is converted into carbon dioxide (or CO_2) while the hydrogen reacts with oxygen to form water (H_2O). Through combustion, chemical energy is converted into heat on the one hand, and into work on the other. We transfer this work from the engine to the driven wheels: in other words, we create a propulsive force so that the vehicle can cover distance and this is how we drive the car.
A summary of engine mechanics is given in the videos available in English and German.

Fuels for Engines

We can distinguish two main ICE architectures depending on the fuels powering them:

1) Spark ignited engines, which can use
    a. Gasoline
    b. Alcohols: (bio --) ethanol, methanol
    c. Gaseous Fuels: Compressed Natural Gas (CNG); Liquefied Petroleum Gas (LPG); biogases (Methane and Carbon Dioxide mixture); Hydrogen

    ➔ Ignition needs to be supported by a spark plug

2) Compression ignited engines, which can use:
    a. Diesel, Biodiesel or Rapeseed Methyl Ester (RME)

    ➔ Self-ignition when temperature and pressure is high enough

Refineries are able to extract from crude oil many different types of fossil fuels each with its specific chemical and physical properties and thus applications. When compared to Gasoline, Diesel properties make IC engines still preferable from fuel consumption (and then CO_2 also) point of view. Crude oil is and will remain in the mid-term time horizon cheap to produce and transport while electricity and H_2 infrastructures still need vast improvement from the logistical and economical point of view. Synthetic fuels and bio fuels can be very good alternatives for the transition period, fighting the global warming phenomenon and still letting time for technological progress. Hydrogen seems to be the most appealing solution over the long term horizon combined with renewable sources and a deeply improved production.

Mixture Preparation & Combustion

Mixture processes and combustion processes define the quality of the power deployment and the emission outcome. The task of the fuel mixture-generation system is to guarantee for each operating condition (engine speed and torque) the correct air/fuel ratio in the cylinder, so that to have enough fuel to supply the desired torque and enough air (oxygen) to complete combustion process. A big variety of mechanical injection system has been developed in the past becoming more and more complex. Finally, by the help of electronic control they became simpler. The control intelligence was transferred into software to realize more efficient devices in many different operating conditions. Basically, gasoline and diesel combustion processes in the chamber are completely different. Gasoline combustion (diffusion combustion) is very homogeneous, whereas Diesel combustion occurs in inhomogeneous conditions.

Exhaust Gas Aftertreatment

Most of ICE exhaust emissions (80%) consist of N_2 and CO_2, then water vapor, oxygen and other gases follow. Only a very little part, nowadays in the range of a few ppm (parts per million) after catalyst, are toxic emissions. Although more than 2000 substances are emitted by the ICEs, the legislation only limits: CO, Hydrocarbons (total and non-methane), nitrogen oxides (NOx – a summarized value of mainly NO and NO2), and particulates (number in sizes). Today, where all ice engines are equipped with an aftertreatment system, most of the emissions occur in the first minute after start, when the catalyst system does not work due to missing temperature. Modern and advanced systems now include both catalytic converter and particulate filter as part of the exhaust system.

Social and Environmental Impact of ICE

ICE and related infrastructure take many advantages from almost 130 years of development and optimization. Our prosperity and economic growth is based on our existing mobility solutions and any sudden changes might endanger this success. Therefore, a transition phase is needed where ICE has still a place. Due to the affordability and convenience achieved and the resulting high number of ICE vehicles worldwide (yearly production about 100 millions) the environmental effects cannot be ignored any longer (especially climate change) and alternatives need to be brought into the market. Electric propulsion in/for all vehicles promises to be a good solution especially on local level in the upcoming mega cities all over the world. It improves dramatically the local emissions (toxic and noise) situation. Over longer distances electric propulsion powered or supported by hydrogen operated fuel cells seem to be the proper solution. Life Cycle Analysis – as the only scientific approach – shows that electric vehicles will improve significantly the CO_2 footprint only when used for a long time or kilometric distance. Concerning production and recycling, the EV is inferior to conventional vehicles. The positive effect of EVs in the ‘’use-phase“ is better when electricity is produced by renewables (wind, water, solar). To make e-mobility a success and a real benefit for the environment, our complete energy system must rely on renewable sources. An H_2 based energy system might be the long term solution. All problems related to mobility and personal usage can only be solved by new transport solutions and by adapting our personal behavior.

MOOC Week 4: BATTERY & LIGHTING SYSTEMS

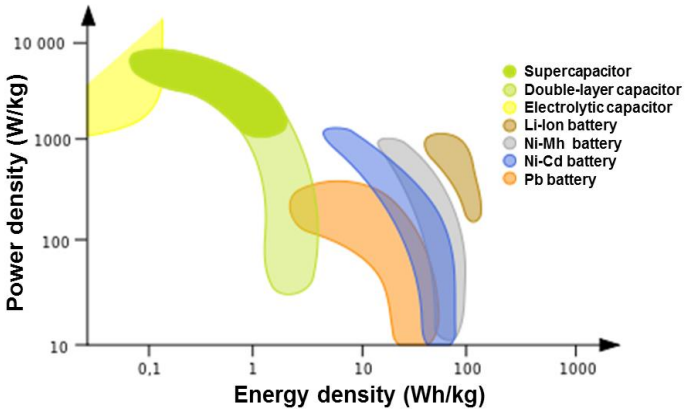
General description of the module

The goal of this module is to introduce the teachers to how the battery systems are implemented into modern vehicles. It should provide an overall understanding of how the field of knowledge from various science areas can be applied to modern vehicle battery systems.
Another goal of this module is to introduce the teachers to how headlamps and rear lamps are used in cars and to provide a system engineering understanding which allows teachers to assign experiments at school and content learned at school to specific Automotive functionalities.

Basic terms & concept of battery

Basic principle for all battery types is an electrochemical reaction. Batteries convert chemical energy to electric energy. A battery consists of cells, case and terminals. Each cell consists of electrolyte, positive and negative electrodes and separator. Anions and Cations are the ions which carry the charge. Anions are negatively charged ions and anions are the positively charged ions. Electrolyte is a chemical liquid-like medium lead acid, nickel cadmium, lithium iron. Separator is used to prevent the passage of metals, particles of the active matter and the sludge from the electrode of one polarity to the electrode of opposite polarity.

Common battery types found in automotive applications



Lead-acid batteries
Nickel-Metal hydride batteries
Nickel-Cadmium batteries
Lithium Batteries
Lithium ion batteries
Lithium polymer
Lithium oxygen
Lithium sulphur

Figure 1 Power vs energy density by Elcap is licensed under CC0 1.0 Universal

Battery Management Systems

The BMS (*Battery Management System*) is one of the most important units in electric vehicle. An electric vehicle often requires fast and high current during the processes of charging and discharging, especially in HEV (*Hybrid Electric Vehicle*) applications. The BMS is an electronic system that manages cells in battery pack. The BMS is connected to the battery cells through a multitude of wires. The control unit is used to measure, estimate, and predict the operation possibilities for the upcoming time period.

The BMS must be able to decide whether the power from the source can be accepted or delivered to load, in order to keep the up with the vehicle performance. The control strategies used determine optimal energy usage and the battery life.
The communication through communication interface between all control units in real time, according to the rapidly changing driving conditions is crucial for a proper operation.

The BMS must to provide these following basic function:

- protect the cells or the battery from damage,
- prolong the life of the battery,
- maintain the battery in a state in which it can full fill the functional requirements of the application for which it was specified,
- monitor the conditions of individual cells which make up the battery pack, maintain all the cells within their operating limits.

Battery influences on the environment and human health

Batteries are made from a variety of chemicals, and metals which are in the batteries for the chemical reaction. Some of these materials are extremely toxic and poisonous, such as nickel, cadmium, lead, mercury, zinc, manganese, cobalt, chromium, vanadium and lithium.
Air pollution: Batteries are decomposed in landfills; the process of photochemical reaction takes place in the battery. It causes to the greenhouse effect, that is results in global warming / climate change.
They cause soil and water pollution: they do damage to soil micro-organisms and affect the breakdown of organic matter.
They threaten wildlife: accumulation in fish, it causes a reduction in their population.
New techniques used in electrochemistry can possible reduce the impact of battery on the environment and human health. Rechargeable battery systems have obviously a great advantage in this respect since they may be recharged and reused many times. More efficient waste sorting, reusing and component disposal of batteries.

Basic concepts of modern lighting systems

Adaptive front lighting system is one part of the active safety system of a middle- high end passenger car, providing an optimized vision to the driver during night time and other poor-sight conditions of the road by adapting the headlight angle and intensity, and judging the speed of the car, the steering wheel angle, the weather condition, and yaw and tilt rate of the car.
Oncoming traffic often forces the driver to dip the beam in order to avoid glaring of a traffic participant using the high beam. New lighting systems allow driving with high beam without glaring, because system use masking technique. It means that driving with permanently switched in high beam is possible by creating one light tunnel in time. This System is known as Camera based AFS – Glare free high beam system. Improvements of this system provides Camera based AFS – Matrix beam system, which can create more light tunnels on scene and get rid of mechanical system (rotating drum, stepper motor, gear …) to fully digital. Matrix LED system consist of Camera, Matrix LED control unit and Matrix LED light modules.

Energy Management

What is an Ecological Footprint ?

…measures human demand on nature, i.e., the quantity of nature it takes to support people and their lifestyle or an economy.

What is Global Warming?

…the greenhouse effect is a natural process responsible for keeping the earth at the temperature needed to sustain life.

Selfdriving Cars

What is a Selfdriving Car?

- Sensing the environment
- Navigating without human input
- Communicating with traffic participants
- Making saftey-relevant decisions

Physical Principles

…Radar

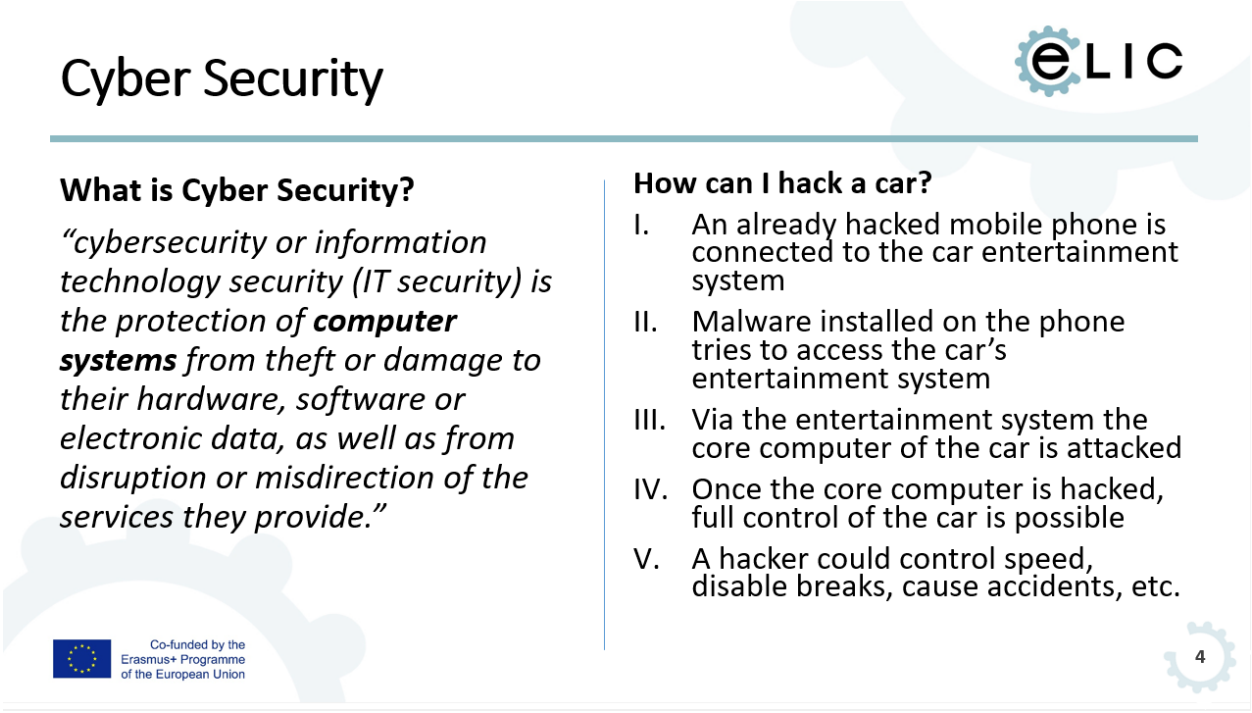
- Blind spot assistance
- Adaptive Cruise Control (ACC)
- Emergency brake

…Lidar

- „Eyes ofthecar“
- 360-degree view
- City break
- Stop& Go

…GPS

- Navigation of the vehicle
- Route planing
- Very important for the Auto Pilot



MOOC Week 6: Certification System

The test and certification is based on the following concepts

(1) Life Long Learning Strategy

The European Commission and the Erasmus+ program emphasise the continuous education of teachers. The member states are asked to support this program so that e.g. cities like Berlin started a mandatory continuous training program for teachers where teachers receive points. See https://www.news4teachers.de/2017/07/fortbildungen-punktekonto-fuer-jeden-lehrer-und-die-schulleitung-solls-kontrollieren-gew-buerokratiemonster/ .
While the establishment of EU programs takes time to be placed in member sates it happens to be implemented in all member states over a period of time. This effectively means that teachers still being years in work will become part of life long learning strategy programs in Europe.

(2) Certification Approach

European recognition requires certification based on a comparable schema. This means that teachers across all regions of Europe will have a same type of exam for the same set of skills and the certificate will be the same across all regions.

For that reason, an ISO 17024 international standard for personal certification regulates how such exams shall be organised and that the exam body shall be separate from the training body. Also European certification platforms (e.g. ECQA European Certification and Qualification Association) developed exams and mapped them onto the ISO 17024 criteria.

In ELIC the ECQA certification system has been adapted (update of software programs of ECQA) to support MOOC based exams and certification. Attendees can register, do the exam and the certificate is generate and sent by email to the person.

(3) Value of the Certificate

ECQA provides a certificate which is based on ISO 17024 guidelines and is comparable across all European regions. ECQA certificates are used in various cases already (Certified Terminology Manager for all translators in the European Commission, Certified functional safety manager for lead Automotive industry, innovative teacher certificates issued in Austria, Hungary, Slovenia, etc.).

(4) How to Access

The exam registration and performance is available at:

https://www.ecqa.org/index.php?id=58&domain_id=123&organisation_id=191

(5) Do you need a certificate?

Still countries in Europe have different law.

The law in Austria (until 2019) only foresees mandatory continuous learning of teachers at secondary and not Gymnasium level.
In Germany there is a general law that all teachers need continuous education and some cities (e.g. Berlin) started measuring it.

The European Lisbon treaty (2010) asked the member states to work on continuous learning programs for teachers and left the control of it to national states. This effectively means that it is a free choice for teachers to do the exam and receive a certificate.