Guidelines for the

transferability of the model

Project: **“Learning e-Mobility plus”**

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0.1 INFORMAZIONI DI BASE SUL PROGETTO

Baisc project informations	
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Purpose of the document:	

Intellectual property of the document	
Name and address of the Company	PIA SOCIETA' SAN GAETANO
Telephone / Fax	+39 0444933112 / +39 0444933115
E-Mail	segreteria@sangaetano.org
Internet	www.sangaetano.org

Intellectual property of the document	
Name and address of the Company	CONFARTIGIANATO VICENZA
Telephone / Fax	+39 0444392300 / +39 0444961003
E-Mail	info@confartigianatovicenza.it
Internet	www.confartigianatovicenza.it

Intellectual property of the document	
Name and address of the Company	EUROCULTURA
Telephone / Fax	+39 0444964770/ +39 0444189012
E-Mail	info@eurocultura.it
Internet	www.eurocultura.it

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1 ORIGIN OF THE LEARNING SYSTEM

1.1 DEFINITION AND OVERVIEW

For a good understanding of the project's choices and characteristics as well as to efficiently repeat the presented project it is necessary to understand the context of reference:

1) The project has been applied in an environment in which the professional education is conducted exclusively in Education Centres, with both theoretical and practical approaches. In order to transfer the project in an environment where this activity is carried out according to a dual system, it is necessary to take all the adaptations needed.

2) The starting scenery of application of the model highlights a limited diffusion and a poor sensibility to the theme of electrical mobility and little attention is given to specific training in the local area. Some of the planning and execution choices of the didactic model also have the aim of increasing the interest towards the students and to support the diffusion of the theme in the local area.

1.2 AIM AND FIELD OF USAGE

The present document has the main objective of describing to every interested subject all the necessary phases needed to realize the proposed learning model (creation of an electric and hybrid kart to be used in a learning process on the electrical mobility).

For a good use of the present document, it is recommended to look at the Lashtenheft and Pflichtenheft both related to the same model, describing the requirements included in the model and their importance for a good realization of the mentioned learning tool. In addition, the document represents the completion of "Guidelines for the implementation" document, as it may add some further information for a successful execution.

The document can also be used as an independent manual that may give analysis hints and practical advices noticed during the execution phase, especially adopting a flexible view that allows design variation, corresponding to real and specific requirements of every different reality.

1.3 DEVELOPEMENT PHASES

The starting project focused the attention on the hybrid mobility, forecasting the execution of two models, the first one with **sequence connection** and the other with **parallel connection**. The first structure mostly derived from some considerations (which during the project's execution proved to be wrong) over an higher easiness of development, management and execution of an hybrid system compared to an electric one.

The presence of two modalities of different hybrid connections was especially useful to compensate the supposed insufficient ability to make comparisons with a full electric system. The starting plan contemplated a strategy that started with a thermic engine, continued with a hybrid engine and ended up with a next step, eventually outside the project, with an electric engine.

The choice to use karts as means for the learning model derived from the idea of a major attractiveness for the students, who were asked to volunteer for the project.

PROBLEMS AND OPPORTUNITIES ARISED

Problem no.1: Difficulties in the creation of a hybrid system in parallel starting from a combustion engine

Signallings:

- The problem fully appeared in the first execution phase during a meeting with the companies: the execution complexity of the tool clearly appeared, especially form a managerial software's point of view since it had to coordinate the two engines.

- Also during the company visit, the company's technicians suggested to put aside this option since the benefits did not cover the costs of execution and to concentrate on alternative technologies.

Taken decision: to leave the hybrid engine with parallel connection path in order to develop an alternative with a kart with a total electrical traction. The new path incremented **the opportunities of development and diagnostic** and now represents an improvement of the model.

Problem no.2: problems with materials availability

Signallings:

- It was not easy to find materials for the construction especially if comparing prices, quality and times of delivery (most of the materials are of importation)

- Each supplier

Taken decision: for the purchase of the materials two final options for the engines acquisition have been considered, among two suppliers able to supply a fill kit for the assembling of the model. The main choice have been conducted using as criteria of evaluation the willingness of the staff to offer after-sale service, as well as future opportunities of model development and the easiness supplementary material. Also in this case, the choice opened **new opportunities, derived by the use of a more powerful engine**, corresponding to the current technologies used in cars.

ESSENTIAL ADAPTATIONS AND OPPORTUNITIES FOR DEVELOPMENT

According to the emerged and definite problems in the previous section, the final project has been modified in the following way:

Creation of a fully electric kart, starting from a thermic engine kart, and evolution of the same kart through a hybrid connection in series. Following the ended workings and the meetings with the companies of the field, it emerged that the development of hybrid systems, firstly considered the easiest way, actually represents a more complex process than it was thought.

On the basis of the initial premises, the passage to the electric engine had to represent the ending point for a future development of the topic: on the contrary, it emerged that the passage from a traditional traction to a hybrid one resulted in an easier approach for the students, both in a theoretical and practical point of view.

During the intermediate checks with the partners and the comparisons among the parties it resulted crucial to try to transform the different problems in chances of improvement. It is believed that the assembling of a fully electric model represents a development better than a simple project variation.

TIMELINE

It is believed that the time dedicated to the single activities may vary according to the context of reference, but it is highly recommended not to change the phases. The time requested for the writing of some documents derives from the fact that they have been introduced in the learning reality for the first time. Also, not being specific tools for the Italian reality, the creation of these documents required the acquisition of some preliminary abilities.

The knowledge gained thanks to these tools may allow a consistent reduction in time of reproduction of the project or similar ones.

STAGE	Period	Stage Description	Subjects	Duration
PROJECT PLANNING	September 2014	Project analysis and assignments	Project partners	3 hours
PROJECT PLANNING	September 2014	Scenario's analysis	Teachers-Companies-Students	6 hours
PROJECT PLANNING	October 2014	Assignments of working-groups	Teachers-students	2 hours
SUM FOR PROJECT PLANNING				**11 hours**
CONTENTS PLANNING AND LASTENHEFT	December 2014	Definition of contents and abilities	Project partners	3 hours
CONTENTS PLANNING AND LASTENHEFT	December 2014	Definition of technical requirements	Teachers-companies	3 hours
CONTENTS PLANNING AND LASTENHEFT	December 2014	Definition of didactic requirements	Teachers-students	2 hours
CONTENTS PLANNING AND LASTENHEFT	December 2014	Writing of the Pflichtenheft	Designers	40 hours
CONTENTS PLANNING AND LASTENHEFT	January 2015	Evaluation of the Pflichtenheft	Project partners	3 hours
SUM FOR PROJECT PLANNING				**51 hours**
ANALYSIS OF REQUIREMENTS AND OF PFLICHTENHEFT	February 2015	Preliminary analysis of the elements to insert in Pflichtenheft	Project partners	3 hours
ANALYSIS OF REQUIREMENTS AND OF PFLICHTENHEFT	March 2015	Evaluation of Lasthenheft with teachers and students and collection of suggestions	Teachers-students	2 hours
ANALYSIS OF REQUIREMENTS AND OF PFLICHTENHEFT	April 2015	Evaluation of Lasthenheft with partners of the project and collection of suggestions	Teachers - companies	4 hours
ANALYSIS OF REQUIREMENTS AND OF PFLICHTENHEFT	June 2015	Writing of Pflichtenheft	Designers	40 hours
ANALYSIS OF REQUIREMENTS AND OF PFLICHTENHEFT	October 2015	Pflichtenheft update after intermediate evaluation	Designers	6 hours
SUM FOR PROJECT PLANNING				**55 hours**
MODEL DEVELOPMENT – THEORETICAL	April 2015	Theoretical competences definition	Teachers – companies	3 hours

COMPETENCES				
MODEL DEVELOPMENT – THEORETICAL COMPETENCES	May 2015	Preparation of documents and multimedia /traditional material	Teachers	24 hours
MODEL DEVELOPMENT – THEORETICAL COMPETENCES	May 2015	Classes	Teachers – students	11 hours
SUM FOR DEVELOPMENT OF THEORETICAL COMPETENCES				**38 hours**
MODEL DEVELOPMENT – ASSEMBLING	June 2015	Definition of material to acquire	Teachers – companies	2 hours
MODEL DEVELOPMENT – ASSEMBLING	September 2015	Preliminary working on the endothermic kart	Teachers – students	3 hours
MODEL DEVELOPMENT – ASSEMBLING	September 2015	Endothermic kart test	Teachers – students	2 hours
MODEL DEVELOPMENT – ASSEMBLING	October 2015	Components disassembling and preliminary workings for the conversion	Teachers - students	6 hours
INTERMEDIATE EVALUATION	October 2015	Companies' representatives meeting for the evaluation of the results and of the future workings	Companies- teachers- students	5 hours
MODEL DEVELOPMENT – ASSEMBLING	December 2015	Changes definition	Companies – teachers	2 hours
MODEL DEVELOPMENT – ASSEMBLING	December 2015	Students' visit to the company supplier of the electric engine for technical advices	Company - students	5 hours
MODEL DEVELOPMENT – ASSEMBLING	January 2016	Electric kart assembling		15 hours
MODEL DEVELOPMENT – ASSEMBLING	March 2016	Adding of the endothermic engine for the hybrid conversion		3 hours
MODEL DEVELOPMENT – ASSEMBLING	June 2016	Vision of the final product and last comments	Project partners	2 hours
SUM FOR PROJECT DEVELOPMENT - ASSEMBLING				**45 hours**
RESULTS EVALUATION	Mag 2016	Tests on the final karts	Teachers - students	4 hours
RESULTS EVALUATION	June 2016	Evaluation of the learning levels	Teachers – students	3 hours
RESULTS EVALUATION	June 2016	Project evaluation	Project partners	4 hours
SUM RESULTS' EVALUATION				**11 hours**

2. DEVELOPMENT OF THE LEARNING MODEL

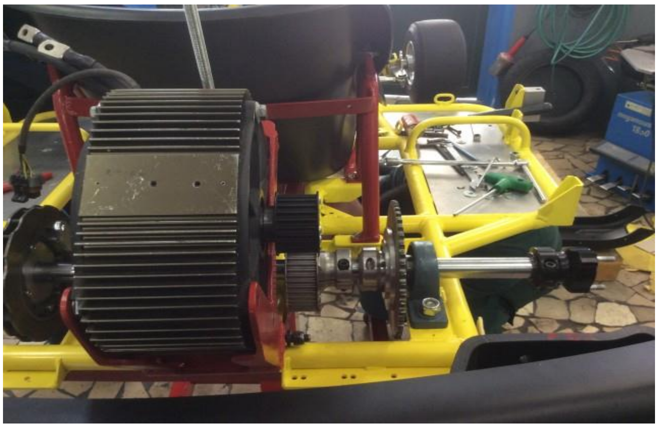
2.1 ASSEMBLING ISTRUCTIONS

NEEDED TOOLS

Per la costruzione del modello sono stati utilizzati i seguenti strumenti:
The following tools have been used for the model assemblage
- Digital mutimeter to create electric connections
- Electric scheme supplied with the engine
- Standard tools set
- Angle grinder to cut the metal and to remove some of the components (if it is intended to start the manufacturing from a basic chassis).
- Lathe and die grinder to modify components such as the drive shaft in order to foresee both the electric and thermic transmission systems
- Welding machine for potential changes to the electric cables
- Drill
- Paint sprayer

<u>Specific components used:</u>

Chassis after components' removal



Engine detail:
(produced by ZeroMotorcycles asynchronous three-phase, with a kit full with 102 W / 25 A ion lithium batteries and connecting cables)
On the engine's left the electric transmission wheel, on the right the wheel for the combustion engine

EXECUTION PLAN
A) PLANNING

a)Starting meeting with the partners to define the students' roles, objectives and key abilities. Specifically:

- Understand the technology of the electric and hybrid systems
- Acquire the main diagnostic methodologies
- Involve and interest the students in this technology

b) Didactic material preparation by the teachers to supply the students with the necessary theoretical abilities

c) Organization of theoretical class interventions to supply the students with basic abilities

REFERENCE PLAN

Prerequisites:
Basic notions on the current regulation related to safety and health in the workplace
Intermediate notions on gasoline and diesel internal combustion engines
Intermediate notions on all the vehicle's components (transmission, steering wheel, etc.)
Basic notions on electro technics related to the vehicles
Basic notions on diagnostics

Method of prerequisites verification: prerequisites are considered automatically assimilated after at least a two-years professional training course for mechanics or a working period of 18 months related to this specific sector. In case of doubts over the prerequisites, confirm may be asked trough an oral meeting with a teacher or another expert partner of the training authority.

For the general parts, the course is oriented to the class (composed by 20-28 students), while the more technical and practical aspects of the course are oriented to smaller groups of students (8 students), who will actively follow the assembling part of the work.

Course programme:
Smaller groups workings are highlighted in bold

Module 1: Safety (approximately 3 hours):
Review of basic notions on the effects of electricity and dangerous intensities
Most relevant components of hybrid and electric vehicles from a dangerous point of view;
Main protective devices;

Dangerous behaviours and prevention measures;

Module 2: Hybrid and electrical technologies in vehicles (approx. 8 hours):
Main components necessary to the electric traction compared with the hybrid traction ones;
Differences between the electric and the hybrid systems;
Types of hybrids and connecting schemes;
Different electric and hybrid models of vehicles in the market and their characteristics;
Examples of some components, reading and interpreting of technical data, preliminary evaluation of the performances;

Module 3 Practical (approx. 2 hours):
Reading of electrical schemes, tools and procedures of testing the connections and the intensity and the realisation of a wiring (example on electric equipment of traditional vehicles)

d) Acquisition of the kart. Selection of pre-owned karts with internal combustion engine to convert with an electric engine.

e) Partners meeting to evaluate the characteristics of the materials to buy for the conversion process, and discussion for possible purchasing options.

B) EXECUTION

a) Internal combustion engine kart test, evaluation of the condition of usury of each component and substitution of the most damaged ones.
b) Meeting for the evaluation of the interventions to do and the modifications to apply at the chassis
c) Complete dismantling of all the elements of the kart in order to obtain a plain chassis

Details of the kart after the components removal and the painting in order to let the structure stand out

d) Meeting with the partners to present the project and the works that are intended to be realised. This should be the occasion to define possible project modifications. In this specific case, the main difficulty was liked to obtain an in parallel hybrid model considering costs and the complexity of the project.

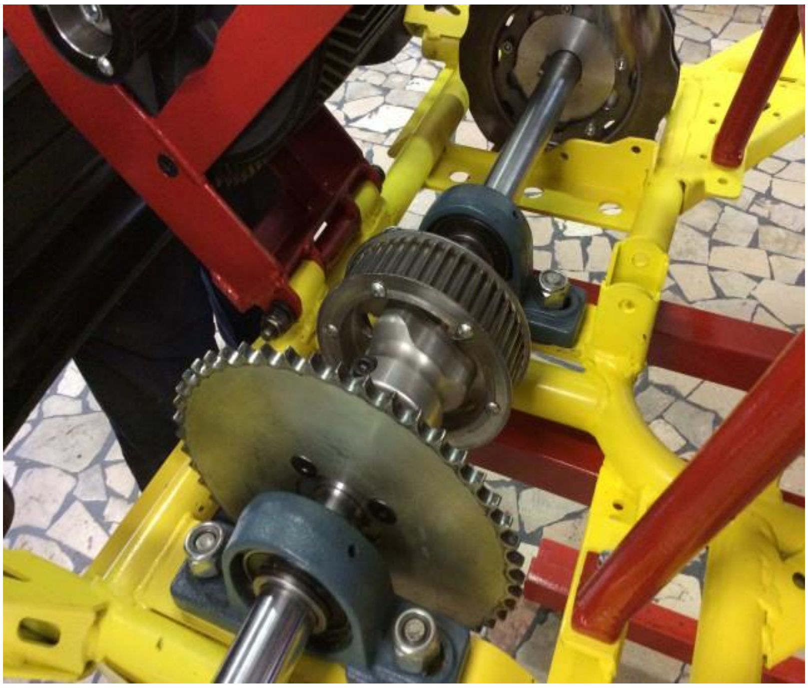
e) Material purchase as a complete kit: ENGINE, SLI BATTERY and WIRING. Students measuring of the components, preliminary preparation.

Detail of the test to evaluate where to position the engine by calculating obstacles and balance.

f) Creation of new clamps and supports for the engine and the SLI battery to position on the kart by using lathe and die grinder

Detail of the new supports (in red); the seat and the engine position are highlighted.

g) Die grinder modification of the drive shaft to centre the pinion used by the electric engine and positioning the one for the internal combustion engine on the right



Detail of the after process transmission

h) Positioning of the seat, pedals and steering wheel at the centre of the vehicle to improve balance

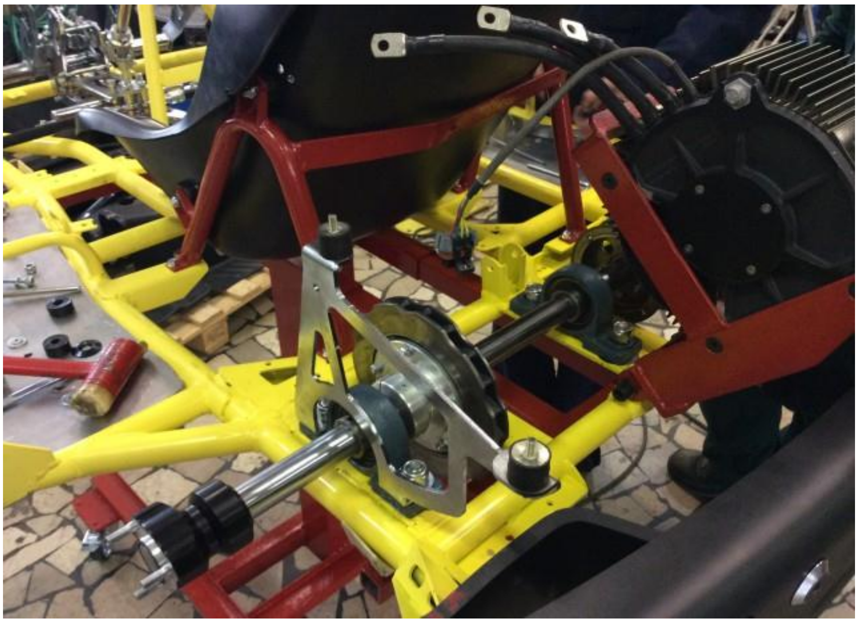
Seat positioned at the centre of the chassis

Pedals positioning

Positioning oh the steering wheel

h) Engine and transmission fixing

Transmission detail (seen from the right: on the foreground the sprocket for the thermic engine)



Transmission detail (seen from the right: on the foreground the sprocket for the thermic engine)

i) Positioning of the SLI battery and realisation of a support for the thermic engine able to transform the vehicle in a hybrid one

Place for the thermic engine to implement an hybrid convertion

Place for battery pack

j) Positioning the control unit

k) Realisation of the wiring following the electrical plan provided with the components and positioning of the original coverings

l) Positioning of the thermic engine, fixing it with specific clamps created with a lathe. Connection through chain at the transmission, leaving also the belt, which connects it to the electric engine – the last one spins freely without ruining the motion. Since the evolution of the project concentrated on a pure electric, the vehicle is not balanced in its hybrid arrangement and consequently is less dynamic.
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C) DIAGNOSTIC

a) Karts check-up:

With charged battery, both karts covered 10 clocked loops with evaluation of precision mean timing and speed

With charged battery, both karts covered 10 accelerations with evaluation of the difference in results

Verify how many loops a kart covers with 1 litre of gasoline

Verify haw many loops the electric kart covers with a full charged battery by alternating at the driving the students who actively participated at the assembling of the model

Measuring of gas emissions of the thermic engine

b) Explanation of the main electrical diagnostic tools and their use

c) Breakdowns simulation:

substitution of a working cable with a defective one

substitution of a working fuse with defective fuses

d) Testing the students on the contents of the intervention

2.2 ASSEMBLING PROCESS

Phase		Tests Critical Points
PLANNING	Measuring the electric components' dimensions and planning of their positioning	Correct measurements are required. While positioning the various components, take in consideration their connections as to facilitate the final electrical wiring. During this phase, all the possible modifications, supports and chassis' additional components should be considered, as to proceed to their making or purchase.
	Acquisition of basic safety notions to operate on electric engines	Before working on electric engines, students should aquire basic knowledge on safetey (the requested skills are a prerequirement for second and third year student), particularly on specific regulations regarding electric components. Teachers have to check that students use specific protection devices and that they work in safe condition.
	Acquisition of necessary technological abilities	Most of the technical competences can be assimilated during the assembling process. The necessary ability previous to the works is the ability of reading an electrical scheme as to do the wiring by following a logic and correct procedure.
EXECUTION	Complete kart dismantling to obtain the basic chassis.	At the end of the dismantling verify of the chassis is symmetrical. If it is not, modify the structure as to position the seat at the centre of it.
	Positioning of the engine clamps behind the seat, in a central position of the	Verify if the pulley (which transfers the rotating axle and engine movement)

	chassis as to obtain proper balance.	does not have obstacles, which have to be eliminated. Verify if the clamps and the supports applied to the engine are compatible with the energies generated by the engine.
	Alteration of seat supports and steering column as to positioning them at the centre of the kart.	Particular attention must be given at the measurements of all the components to be weld and to the quality of the more stressed parts, as to avoid chassis damage.
	Reassembling of the chassis components (also the electric engine) for a preliminary test of the quality of the modifications	Measurement of the kart balance
	Possible painting of some chassis' parts for educational scopes or to highlight fixed and moving parts and the final assembling	
	Positioning of battery pack considering the balance, particulary on front wheels.	**Important:** Verify that batteries do not touch lateral protective devices and put under each battery rubber material to insulate. Tie the components with two strap to avoid damages.
	Start the cabling of electric components following the wiring diagram supplied along with the motor. Multimeter should be used each step to verify accuracy.	Check the cable length and their **insulation,** especially if they were extended like in our situation.
	Implementation of electric cabling wiring dashboard, brake and potentiomenter.	Check the technical data of the potentiometer. Our advice is to have the potentiomenter and the engine supplied by the same supplier. In our case, we don't have this opportunity so we have to test different instruments. The first satisfactory results were obtained with a Fiat Croma potentiometer.
	Tests on karts Comparison of models end data collecting.	The testing objectives are not the performances, but the collection of statistical data to work in class with the teachers and to improve the students involvement. ei soggetti interessati. In any case, during test improvement opportunities could be proposed and evaluated.
	Diagnostic	During diagnostic lessons all

		instruments should be presented and teachers have to specify which are the most important components and connections to check.
	Working on simulated breakdowns	Teachers, with the contribution of all involved partners (companies or universities) have to simulate the recurring part failures arranging specific exercises for students.

3. CONVEYANCE ADVICES

- Number of expected addressees: the following educational model is preferably applicable to small groups of students (6 to 12) who have prerequisites in the field of auto mechanics (at least a two-years professional training course). A minor students number may not allow to develop the adequate team working methodologies and problem-solving abilities, while a larger number may cause problems of group-managing. It may be of interest to have mixed groups of second and third year students, in order to develop specific abilities of team working and problem solving and observing the way the students work together.

- For some works it was necessary to use traditional machine tool. It is necessary to evaluate if the students have these abilities (in auto mechanic courses theory of basic mechanic is usually issued) and if the needed machinery is at disposal (alternatively some works need to be done outside).

- It is not recommended to start from a thermic engine to end with a hybrid one. The procedure that takes from an electric to an hybrid engine is simpler and of immediate understanding for the students.

- It is recommended the reasoning together with a scientific teacher over the forces that have effect on the kart and on the more stressed parts, especially in case of a full used power engine. For the model production, the final power was intentionally limited in order to prevent excessive strains. Every power increase must consider a deepening in the study of applied physical forces.

During the works, the students created a WhatsApp group opened to the teachers and to some companies representatives willing to participate. This tool proved to be very useful for sharing and solving problems, and pushed some of the students to independently research information on new technologies and ask for opinions, while sharing the received information. This tool finally proved to be a good way of self-learning for the students.

- It was noticed that the use of multimedia materials for theory classes helped the active contribution of the students. This did not happen during traditional classes.

- It is suggested to have periodical meetings and debates for **preparation, planning and evaluation of the work** with the companies, but not during the works with the students. In fact, in the professional education, students may feel frightened and my directly ask for the solution without actively searching and reasoning for it.

- For the components assembling it is suggested to start from a plain chassis, directly purchased or obtained trough removing all the components; in fact, it has been noticed that finding a way of adapting the components for the electric engine to the space at disposal is much more complex than creating the electric traction and adapting the other parts.

- Lessons on electrical safety must be held BEFORE starting all the works, while lessons on technology could also be held work in progress (it is usually preferable because it helps the students to facilitate the concepts learning).

- For a better evaluation and application of the project, it should be reminded that the students' participation on the theme of electrical mobility was one of the main objectives, thing that is secondary in our national context. Some of the activities or the simple choice of the vehicle (kart) are functional to this aim, as well as the choice of leaving apart some technical contents and the dimensioning of the deepening of practical activity. In a context where the theme is debated in deepen and for more time, the relationship between the time for theory and practice should obviously be varied.

- It is suggested the use of specific tools and to dedicate specific time to final diagnostic activities, one of the most requested skills from the companies, activity which has great importance also during stakeholders meetings. As for the specific experience of the project, during the companies and students meeting great importance was given to diagnosis, especially in the electrical field, helping the following teacher work.