D.E.L.T.A.

Drones:

Experiential Learning and new Training Assets

Intellectual Output 1

ENGINEERING PROGRAMME

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Partners' List

NO.	PARTNER	SHORT NAME	COUNTRY
P1 - COORDINATOR	**CISITA PARMA Scarl**	CISITA	Italy
P2	Aerodron Srl	Aerodron	Italy
P3 **OUTPUT LEADER**	**IIS "A. Ferrari"**	Ferrari	Italy
P4	IISS "A. Berenini"	Berenini	Italy
P5	IISS "C.E. Gadda"	Gadda	Italy
P6	Centro Público Integrado de Formación Profesional Corona de Aragón	Corona de Aragon	Spain
P7	Fundación AITIIP	AITIIP	Spain
P8	Liceul Teoretic de Informatica "Grigore Moisil"	LIIS	Romania
P9	SC Ludor Engineering Srl	LUDOR	Romania
P10	Universidade Portucalense Infante D. Henrique – Cooperativa de Ensino Superior Crl	UPT	Portugal

Introduction: why Drones

At the threshold of 2020, the EU scenario in terms of education and vocational training shows a gap: on the one hand, the strong pressure of the labor market which is the constant and growing search for profiles with strong STEM skills (mathematics, science, techniques and engineering); on the other hand, there is an inadequate level of STEM skills in the secondary cycle student population, in which about 22% is below the average of skills and knowledge with respect to their European peers, with peaks of 36% in the case of a partner disadvantage -cheap. A gap that widens further if we consider the gender gap, due to the fact that a still insufficient number of girls approach the technical-scientific culture.

As a result, while 90% of jobs in the next 10 years will require STEM skills, with over 7 million jobs available or being created in this area, it is estimated that the disalignment between education and the labor market costs to the EU the lack of 825,000 skilled workers.[1]

To tackle these critical issues, the EU 2020 strategy, already expressed in the "Joint Report of the Council of the ET 2020 - New priorities for European Cooperation in Education and Training (2015) focuses on a innovative concept of education and training:

- hoping for an educational process more focused on the learner and personalized, also with a view to overcoming the gender disparity in access to the fields of knowledge STEM
- betting on technology as a tool able to connect theory and practice, STEM subjects and concrete objects in the physical space, as well as the training path and the career path
- rehabilitating and enhance non-formal and informal learning paths, to complement traditional theoretical and frontal learning
- Work-based learning is promoted in the form of self-managed project work by learners, as a tool to recover and reinforce the motivation of disadvantaged students or students with low academic performance
- A new role is proposed for VET teachers, who become facilitators and mediators of the learning process, rather than knowledge providers, also thanks to the updating of teaching and pedagogical methods

[1] Sources: Eurydice report “Sviluppo delle competenze chiave a scuola e in Europa: sfide e opportunità delle politiche educative”; Eurydice Europe Report “Structural Indicators for monitoring education and training systems in Europe – 2016”, cft Eurostat, section “Education & Training”, “Europe 2020 indicators”.

From these assumptions the idea of the DELTA project was born, which aims to make an innovation contribution to technical and professional training courses at European level, promoting the learning of the STEM curricular disciplines through the work based learning methodology, through the use of harmless drones as a technology in use.

It should be pointed out right away that drones are not the end of learning, but the means that allows secondary school students to deal with mathematical-scientific disciplines, often perceived as difficult and discouraging, through a technology applicable to concrete aspects of everyday life , transferable to a context of participatory and collaborative learning, in which students are placed in a community of practices in which they take personal responsibility for and personalize their study path.

According to MIT Technology Review of 2014 (10 Breakthrough technologies) the drones would have become one of the 10 technological innovations with the greatest impact on the world economy, and the forecasts were not slow to come true. Drones are proving to be strategic for many harmless and civil purposes: rescue missions after catastrophic events, such as earthquakes and the transport of life-saving drugs; mapping of buildings to identify risks related to asbestos; environmental monitoring to avoid deforestation and hydrogeological risks; security control in high-traffic public places such as stations, airports, events; border control; urban and interurban traffic monitoring; video footage for film and documentary activities; precision agriculture; transport and delivery of light goods.

The idea behind the project is the adoption of inoffensive drone technology as a means to improve STEM skills in VET students and to develop technical and professional skills that prepare them to enter the labor market more easily by strengthening their employability. The technology of drones is combined with many aspects present in the European STEM curriculum, easily exploitable and transferable in terms of construction of teacher-led educational programs, invested with a new role of facilitator of learning, bringing theory to laboratory practice. The application of STEM theory to a real object will help teachers to involve and motivate students, especially those with low profit and / or special needs and learning difficulties. In fact, it is believed that VET students are more inclined to learn theoretical concepts through practical activities than through traditional teaching methods in which the teacher only explains concepts and assigns tasks and exercises.

On the basis of STEM educational programs developed by the teaching staff in a teacher-led perspective, the students cooperated in a community of practices inserted in a situated learning context that simulates the work-place, to study, disassemble and build inoffensive drones or parts of they, according to a logic of work-based learning.

This was possible thanks to the strategic cooperation implemented within the partnership, established on the basis of the following criteria:

a) By type of partner

Education side

- Coordinator Cisita Parma, training institution with skills in planning training and learning paths

-5 VET schools selected from 3 EU countries (Italy, Romania, Spain), equipped with technical, professional IT, electronic, mechanical-engineering, scientific curriculum

-1 University (Universidade Portucalense, Portugal) equipped with Department of Computer Science and researchers in the field of digital technologies for situated learning

Business side

-1 company expert in the development of digital applications for the use of drones in civil and industrial (Italy)

- 1 engineering firm expert in automotive solutions, as well as development of engineering applications for learning purposes (Romania)

- 1 research center expert in technological applications on plastics, engineering and automotive, also in aeronautics (Spain)

b) By combination on a territorial basis and by logic of "industrial chain":

working groups have been set up at national level to facilitate collaboration thanks to regional and linguistic continuity.

In particular, the following nerve centers have been identified:

Italy

1 training institution with skills in planning training and learning (Coordinator Cisita Parma)

3 VET schools located in the Emilia Romagna region specialized in engineering and electronic disciplines

1 company expert in applications for the drone industry

Romania

1 VET school specializing in computer science and programming

1 company expert in technological, engineering and digital applications

Spain

1 VET school specializing in industrial chemistry, engineering and automotive disciplines

1 research center expert in technological applications on plastics, engineering and automotive, also in aeronautics

Based on the discussion, D.E.L.T.A. following fundamental objectives have been set:

- Tackling phenomena of school dropout and student motivation, implementing teaching strategies that favor the acquisition of STEM disciplines according to an experiential and practical approach more suited to the learning style of VET students
- Familiarize VET students with inoffensive drone technology, as a pretext for the practical application of formal mathematical-scientific languages traditionally taught with a theoretical approach
- Create learning environments in situation, thanks to the co-planning, by educational institutions and companies, of a work-based learning setting, organized according to the production / industrialization logic of a drone
- Strengthen the professional skills and employability of VET students
- Updating and strengthening the teaching skills and methods of VET teachers and trainers, through the full integration of technological tools, digital applications and their potential

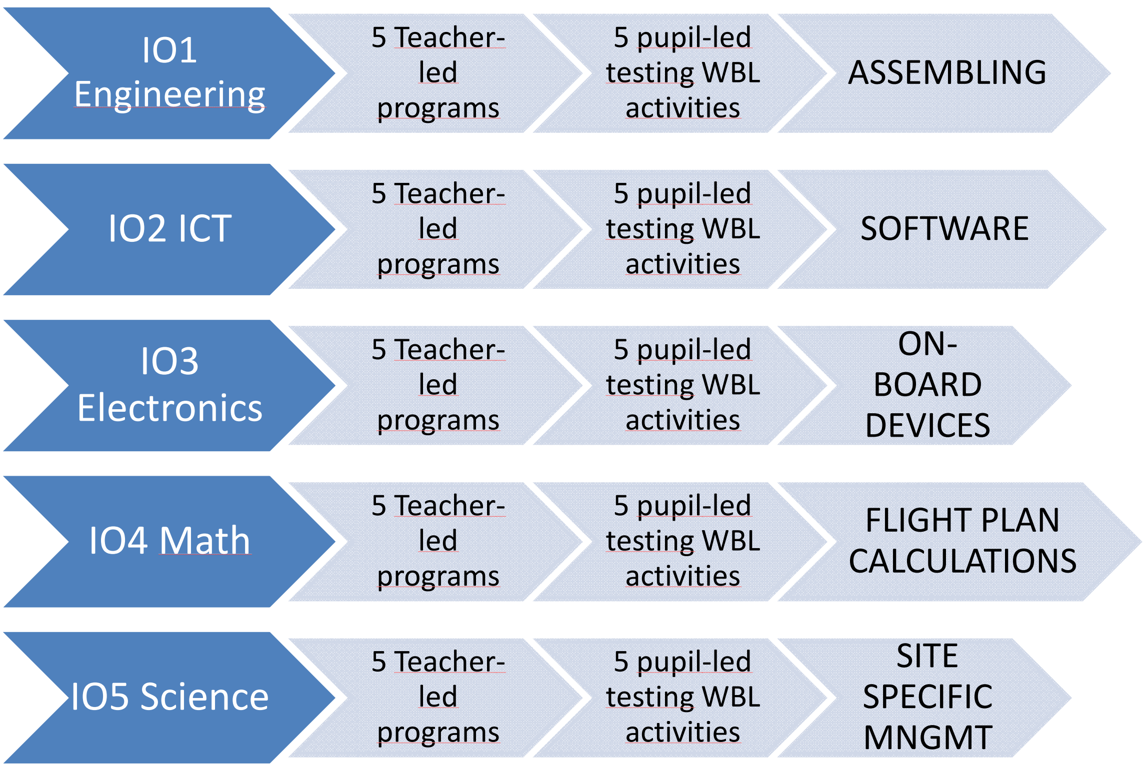

Figure 1 – General structure of D.E.L.T.A. project

The general structure of the D.E.L.T.A. project has planned to proceed according to the logic of the industrialization of a harmless drone, identified in the phase of operational co-planning thanks to the synergy between educational and training institutions on the one hand (P1 Coordinator + P10 University of Porto), and on the other the business oriented partner with special reference to P2 Aerodron by virtue of the specific skills of the sector.

In production, in fact, a harmless drone must be:

1) Designed, manufactured and assembled

2) Configured from the point of view of the software, determining the conditions for the study and processing of data on the ground

3) Configured from an electronic point of view, identifying and implementing the devices to be installed on board

4) Scheduled to follow the correct flight plan trajectory

5) Planned to carry out a mission identified according to a useful application for civil and / or industrial purposes.

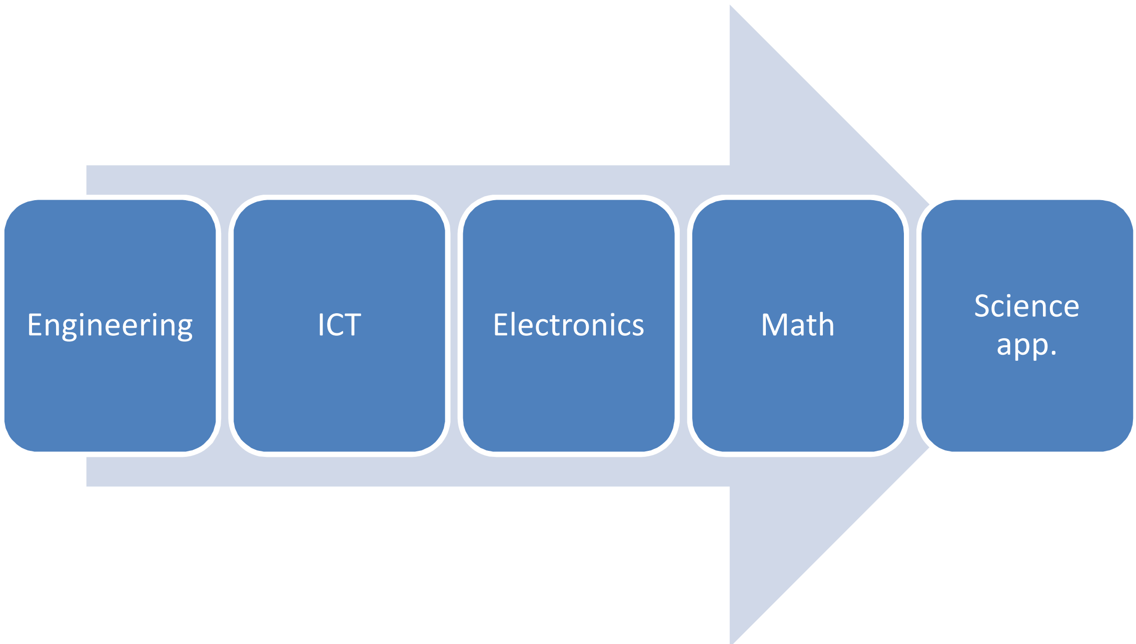

Figure 2 – The process of industrialization of an inoffensive drone

Each of these phases can be easily implemented in a context-based learning context, organized through the teaching methodology of work-based learning from a pupil-led project work perspective, based on the collective and laboratory resolution of a concrete problem.

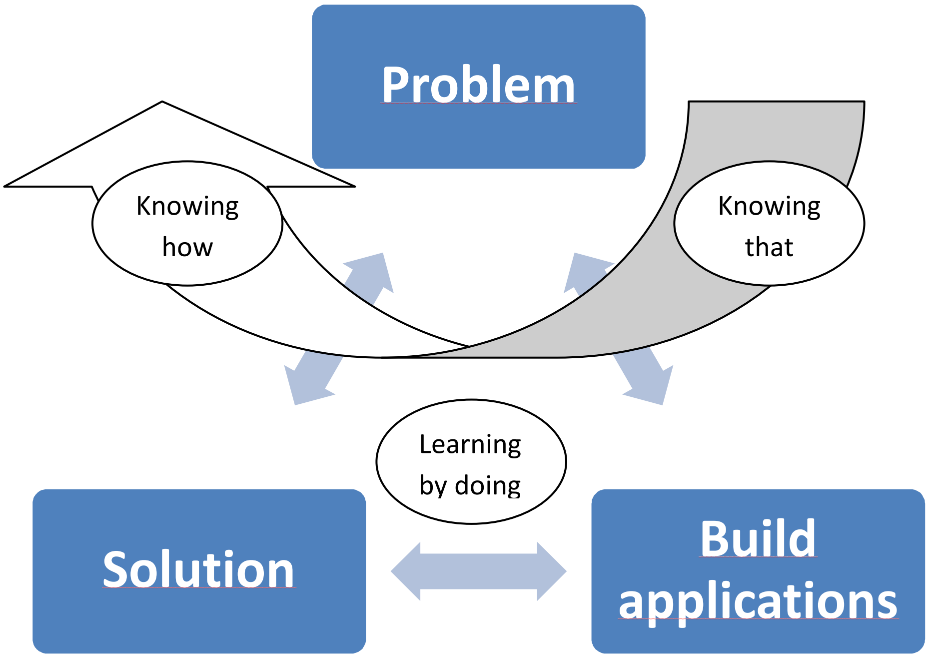

Figure 3 – Scheme of application of Work Based Learning didactic methodology

The students, organized in work groups that identify an emerging community of cognitive apprenticeship practices, are confronted with a concrete problem to be solved, linked to the construction or study of a harmless drone or its components. Immediately they must activate prior knowledge related to their informal or non-formal knowledge, as well as to formal languages learned in the institutional educational context, cooperating to identify applications, strategies and techniques to obtain the solution to the problem faced. In this way they pass from "knowing what / to" to "knowing how" a phenomenon occurs or manifests itself.

Each phase of the drone industrialization process lends itself to multiple modes of use within the VET educational curriculum, since it requires the study and mastery of formal mathematical-scientific languages, both the predisposition of a learning environment that simulates the organization socio-technical work-place.

Through the phases of the D.E.L.T.A. project, thanks to the interdisciplinary approach, the VET students were able to develop:

a) Professional skills relating to key technologies of the digital age, such as information technology for on-shore processing of data collected by the in-flight drone (IO2) and electronics for the assembly on board of aircraft of cameras, components of sensors (multi-spectrum, thermal, "sense & avoid" vision for in-flight interaction) and geolocation (IO3);

b) STEM curricular competences: engineering for the design, production and maintenance of inoffensive drones (IO1); mathematics, through trigonometry for setting the flight plan, and 3D modeling through the point cloud for volumetric calculations and remote sensing (IO4); physical and natural sciences to contextualise the problems that can be faced thanks to the technology in use - such as precision agriculture, environmental and hydrological monitoring (IO5).

The Output consists of a set available for reuse, released in OER (Open Educational Resource) mode, of educational experiments related to the operations of design, production and assembly of inoffensive drones, organized according to the logic of work-based learning in a simulation context of the company production department.

The activities of the Intellectual Output are substantiated in a teacher-led educational program, related to engineering, mechanical and maintenance subjects, for the performance of the disciplinary school curriculum in work-based mode. The program prefigures the conditions for the repeatability of the experimentation and for the pedagogical organization of the work-based learning setting, so that it is as self-managed as possible by the students in project work pupil led mode. An integral part of the Output are the physical objects and the products of experimentation, documented through videos and photos of the situated learning environment.

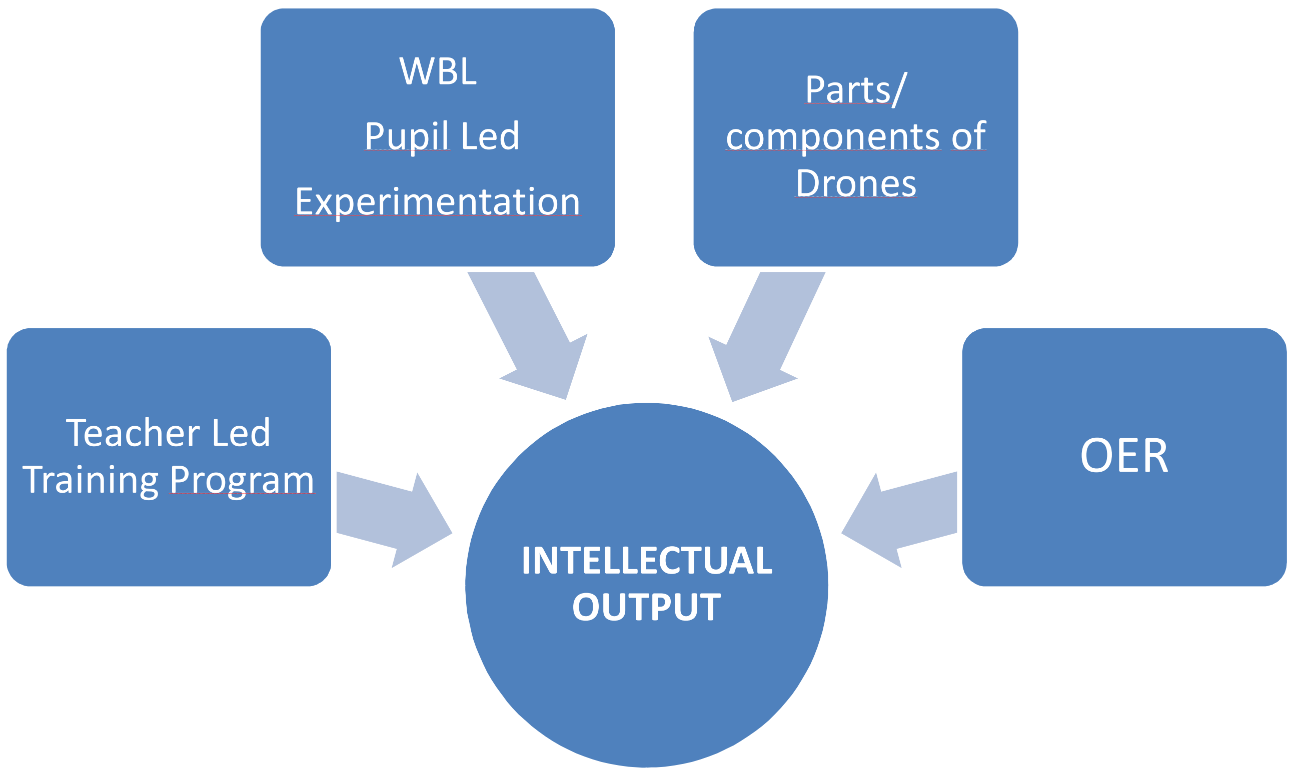

Figura 4 – Structure of the Intellectual Output

Intellectual Output 1 consists of three distinct operational phases: Design - Test - Release, each identified on the basis of key target groups, organized educational and pedagogical environments, the technologies adopted and the activities actually performed. Output Leader is identified in P3 IIS "A. Ferrari "of Maranello (Modena), a VET institute with a strong engineering and automotive vocation, thanks to the privileged relations with the company Ferrari SpA, which is present in the Institute Council, and above all to the excellent curriculum in the field of construction and maintenance of means of transport, repair, maintenance and technical assistance.

Phase	What	Who
Phase 1. DESIGN	1.1 Definition of the Learning Objectives 1.2 Design of the Training Programme 1.3 Didactic design of the experimentation	Leading Partner P3 together with P1 defines the guidelines for the identification of the learning objectives All schools identify Learning Objectives and plan the experimentations Business Partners support schools in the Design and creation of the work-based learning setting
Phase 2. TESTING	2.1 Testing 2.2 Monitoring & feedback	All schools with the support of business partners
Phase 3. RELEASE	3.1 Fine tuning of the Training programme for validation and replicability 3.2 Release in form of OER	All schools

The theoretical approach and the methodological framework that supports the educational experimentation of the Intellectual Output finds its scientific model in the theory of the Activity Sector of Yrjö Engeström (1987). According to this model, the learner in his learning path is confronted with physical objects (the drone in this case) and technologies (mechanical and engineering for IO1) that represent the tools for solving a practical problem that the field of activity proposes. The solution, the new object or the new technology in outcome represents the result of the activity itself. However in this learning process the learner is never alone, but in the field of activity he finds himself inserted in a community of practices, in which other learners live together at the same level, with which he can exchange knowledge and skills according to a peer-relationship. to-peer, as well as trainers and teachers who perform a scaffolding function supporting and facilitating the process of acquiring skills. In this community of practices there are explicit rules and tacit conventions of behavior, hierarchically or more fluidly structured relationships, based on the sharing of responsibilities, tasks and supervision of the same or different technologies. For this reason it can be stated that in the upper part of the framework of the field of activity, which represents the tangible and visible part of the practice, the so-called "hard skills" or technical skills emerge, while in the lower part, submerged and less visible but from the strong influence on all the actors involved, there are the so-called "soft skills" or relational skills.

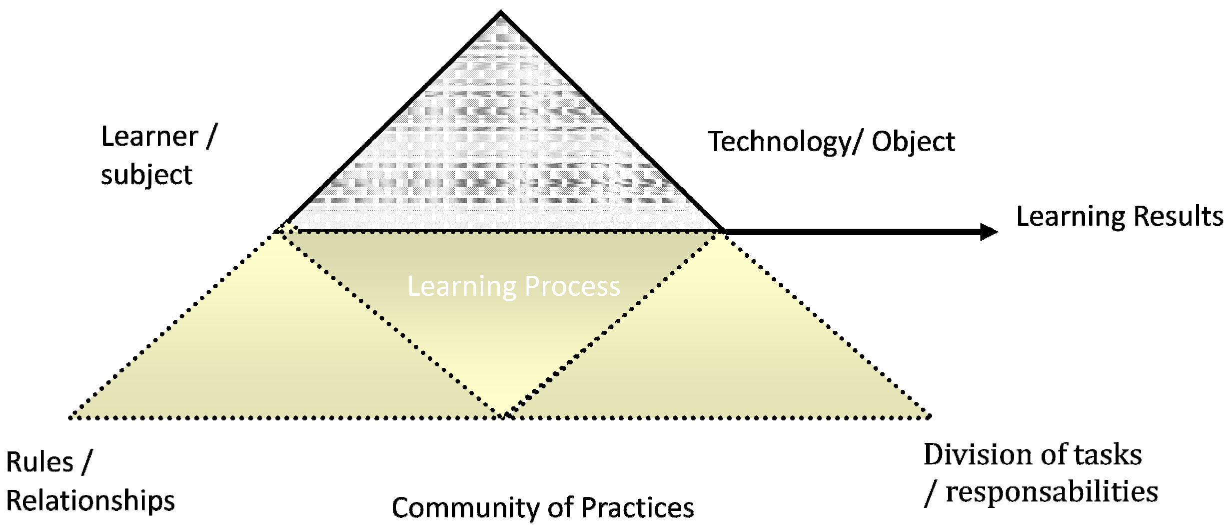

Figure 5 – Grafic representation of the activity theory by Y. Engestrom

The target groups involved in the field of activity exceed the traditional boundaries of the school class, because they involve multiple actors at various levels of responsibility and effectiveness:

- Target group 1: VET students, normally attending the upper three-year course of the secondary cycle, enrolled in mechanics, maintenance and technical assistance, electronics and automation, IT and programming courses. The involvement of an entire class group was planned for each school (around 20/30 students) or an interdisciplinary learning group was established from different classes. A significant part of the learner group was selected based on the condition of greater socio-economic disadvantage and risk of school exclusion due to low performance or motivation.

- Target group 2: VET teachers and trainers with teaching assignments for technologies and mechanical design and electronic plant engineering. Teachers responsible for planning the school curriculum were also involved, as well as those responsible for work-placement activities and curricular internships in local companies. At each VET partner school, a working group specifically dedicated to overseeing the activities of the D.E.L.T.A. project was set up within the teaching staff.
- Target group 3: entrepreneurs and technicians of partner companies, in which a working group composed of experts in applications related to drones, engineering and automotive solutions, as well as business tutors responsible for welcoming students in training during curricular internships, or those responsible for recruiting new workforce.

II.1 Implementation of the Drone Engineering Programme

The activities of each of the 5 participating VET schools will be summarized below, illustrating the objectives, contents and structure of the experiments. Information will be provided on the pedagogical organization of the work-based learning environment, the target group of students involved, the duration and some indications on the curricular objectives achieved or not achieved.

OUTPUT LEADER

P3 IIS "A. Ferrari", Maranello (Modena), Italy

https://www.ipsiaferrari.mo.it/

This is the VET institute originally founded by Enzo Ferrari as a training center for the technicians of the renowned car manufacturer, and subsequently transformed into the State Professional Institute. Currently it includes 3 professional addresses for the five-year diploma (Car-repair, Maintenance of Transportation, Maintenance and Technical Assistance) and 1 address for the technical diploma (Transport and Logistics, Articulation of Construction of the Means of transport).

Already in possession of a Drone model built by graduate students in previous school years, the project team decided to opt for the Reverse Engineering approach, chosen to focus the attention of teachers and learners on the effective understanding of design aspects and assembly of the drone. Starting from the already assembled drone, the students collaborated to dismantle it, measure it, and redesign the mechanical structure of the drone through the use of the SOLIDWORKS program. Thanks to the laboratory use of this 3D modeling software it was possible to design the base, the bodywork or "chassis" of the drone, the arms and the propellers, and then proceed to a virtual 3D assembly of the drone itself.

The learning setting of work based learning is documented with a self-produced video, publicly available on the official YouTube channel of the D.E.L.T.A. Project at the following URL https://www.youtube.com/watch?v=mArvpxo7LuI

Students involved:

About 30 students who have set up an interclass work group as part of the alternating school work activities, coming both from the professional addresses in "Maintenance and Technical Assistance" and "Maintenance of Transportation" and from the technical address in "Transport and Logistics - Articulation Construction of the means of transport ".

Duration of the design phase: about 10 hours

Duration of the testing phase: about 28 hours

Learning objectives

The primary learning objectives were defined based on the outgoing skills profile that graduates from the "IIS A. Ferrari" institute mature: at the end of the five-year course the students must achieve learning outcomes related to the educational, cultural and professional. Specifically, I am able to master the use of technological tools with particular attention to safety in the places of life and work, to the protection of the person, the environment and the territory; they must use result-oriented strategies, work by objectives and the need to assume responsibility in respect of ethics and professional ethics. Students are able to master the fundamental elements of the problem by making observations relevant to what is proposed using an appropriate technical language. Students must also cooperate in group work and engage constructively with teachers, the group of parties and the actors who share in the learning community, while organizing their work, managing the material and making judgments about their work .

Curricular learning objectives:

Knowing the fundamental notions and operations related to forces and moments; Know the basic concepts of statics; Being able to apply the theoretical principles in the study of simple motor machines; Knowing how to read dimensional drawings with indications of tolerances and roughness; Knowing the main characteristics and the use of the main materials used in the mechanical industry; Knowing how to represent the mechanical organs treated during T.M.A. (Mechanical Technologies and Applications); Knowing how to read and correctly interpret the design of an assembly and be able to obtain the mechanical details; Know the parts of an electric motor; Knowing the magnetic forces that induce rotation in an electric motor; Know the specifications of the measuring instruments. Knowing how to read technical manuals and find documentation from alternative sources to school ones.

Extracurricular learning objectives:

The general objective is to train students ready to take advantage of the skills acquired during the course in a professional way. The course is aimed at the acquisition of practical skills immediately applicable in the field.

Knowledge

Introduction to multirotors: Commercial uses of multirotors; Elements of electronics, Volts, Amps, Watts; Main components of multi rotors; LiPo batteries, use, Safety; Commercial flight control units, technical analysis; Drones and Safety; ENAC regulation; Air spaces and airspace classes; Responsible flying: areas where flight is not allowed.

Abilities

Assembly and Maintenance of Civil Drones; Forced flight termination system; Balance the propellers; Make the welds; LiPo battery charger settings; Theoretical multirotor sizing calculations with dedicated software.

From the point of view of behavioral skills:

Adapting the communication style to that of the other party; Listening and understanding the other's point of view; Increasing awareness of the structure of communication processes and manage their contents; Communicate within the group: managing conflicts and building consensus; Develop synthesis skills: communicate in a concise way; Knowing how to communicate and listen in an active and engaging way, relate effectively, a personal and professional competitive advantage.

Organization of the learning environment according to the work-based-learning approach

In class	Work-based learning At school
Frontal and theoretical lessons in the classroom -mechanical elements: machinery - mechanical systems - mechanical design	Premises: Laboratory of Electronics, Mechanics, assisted design (CAD) Equipment: PC, Logic, Multimeter and what can be found in the electronics and mechanical laboratories and how much to buy for the specific realization of the project; Materials: Special parts of the drone (to be purchased ready to assemble, structure to be made of T800

	carbon fiber (an internship was activated for this purpose at the partner company Metal TIG of Castel San Pietro T, Bologna, specialized in the processing of carbon fibers); Conditions of logistic accessibility to the equipment: access to the specific equipment and materials for the project the teachers participating in the project and the students selected from the 3rd and 4th grade classes of the work group. All users have attended training courses on work safety

Scaffolding roles in the situated learning environment:

a.Scaffolding roles inside the shool staff and relevant professionalities:

In vocational education, scaffolding has always been an important teaching technique, reinforced by the role of ITPs (Technical Practical Teachers), support teachers and educators. In particular with respect to the D.E.L.T.A. project the scaffolding figures have had the purpose of:

- enhance pupils' experience and knowledge
- implement adequate interventions with regard to diversity
- to encourage exploration and discovery
- encourage collaborative learning
- promote awareness of one's own way of learning
- carry out educational activities in the form of a laboratory.

The teacher does not determine the learning mechanically. The teacher and the materials he proposes become resources within a process in which learning takes place in many complex ways. The pedagogy of the project has turned out to be an educational practice able to involve students in working around a shared task that has its relevance, not only within the school activity, but also outside it. Working for projects leads to the knowledge of a very important work methodology on the level of action, the sensitivity towards it and the ability to use it in various contexts. The D.E.L.T.A. project, in fact, has been and can be a motivating factor, since what is learned in this context immediately takes, in the eyes of the students, the figure of tools for understanding reality and acting on it.

b. Scaffolding roles outside the school context:

1. Company Metal T.i.g. Srl of Castel San Pietro Terme (Bologna), with technical experts in the lamination and cutting of carbon fibers

2. Professionals of the P2 business partner Aerodron of Parma, by virtue of the following professionalism and technical skills

Founder & CEO of AERODRON. Electronical engineer, pilot.	Sales manager also responsible for public administration projects. Expert in technological innovation.	2 experienced UAV pilots, with a qualification recognized by ENAC. 1 pilot is also a geologist and an expert in photogrammetry and digital applications

P4 IISS "A. Berenini", Fidenza (Parma), Italy

https://www.istitutoberenini.gov.it

It is an institute with both VET study courses (Mechanical Technician, Electronic Technician / Automation, Chemical Technician) and high school (Scientific Applied Sciences option).

The project team decided to involve in the experimentation about 20/25 students of the VET address in Electronics / Automation, which also combines mechanical design skills with the knowledge of electronic circuits and systems and Arduino boards.

As a project activity, the school proceeded to design, model and 3D print components and parts of a DJI Spark F 450 drone, commercially available at low cost. The opportunity was provided by the weight of the purchased drone, equal to 338 grams. However, according to the provisions of article 12 paragraph 5 of the ENAC (National Civil Aviation Authority) Regulation on Remote Piloted Aircraft, a harmless drone must weigh a maximum of 300 grams.

The students then received the delivery to evaluate which parts could be disassembled without causing damage to the drone, and to find a suitable solution for its lightening.

The students then dismantled the propeller protection guides, the protection rings for the LED signal lights and the upper covering part equipped with ventilation ducts for cooling the engine and the drone battery, thus obtaining a resulting weight of 284 grams.

A perfect scenario was presented for the organization of a work based learning setting based on problem solving: how to replace drone components that originally weighed 54 grams, having only 14 grams of waste available?

The solution was sought in the design and 3D modeling of the parts to be replaced, thanks to the Fusion 360 Autodesk CAD software in the cloud, free for educational and didactic purposes. The pieces designed were subsequently produced in PLA material thanks to the 3D printer, which allows to obtain very light components: at the end of the operation the drone reassembled with replacement PLA pieces weighs 291 grams, thus leaving open the option to add a few grams in weight by strengthening the propeller guides for greater flight efficiency.

The learning setting of work based learning is documented with a self-produced video, publicly available on the official YouTube channel of the D.E.L.T.A. Project at the following address https://www.youtube.com/watch?v=V3lxdQ_UQoo

Students involved:

n 20/25 students of the Technical Electronic and Automation (class IV)

Duration of the design phase: around 12 hours

Duration of the testing phase: about 30 hours

Learning objectives

Curricular learning objectives:

1. LIFT - acquiring the ability to choose, test and size electronic and mechanical components and devices relating to flight capacity (propeller, engine, ESP and batteries) and autonomy trying to maintain weight within 300g;

2. FLY CONTROLLER - learn about the development environments and study and modify code fragments that manage the flight of the drone;

3. SELF-CONSTRUCTED DRONE FLIGHT MANAGEMENT SOFTWARE - acquire the ability to manage the flight plan of the self-built drone;

4. COMMERCIAL DRONE FLOOR MANAGEMENT SOFTWARE - acquire the ability to manage the flight plan of a commercial drone;

Extracurricular learning objectives

3D CAD - acquire CAD mechanical design elements and 3D printing of the drone frame

Prerequisites of competence in access: basic knowledge of electronics, mechanics (force, energy, power), computer science (programming in C, basic algorithms).

Skills:

CAD: mechanics, physics, computer science; PORTANZA: electronics, physics, mathematics; FLY CONTROLLER: electronics, systems, information technology, mathematics; FLIGHT MANAGEMENT SOFTWARE: systems, information technology.

Organization of the learning environment according to the work-based-learning approach

CLASS phase: introductory elements on CAD design software; elements on 3D printing; elements on brushless motors and their driving; elements on lift as a function of the propeller; elements on the functioning and development environment of a fly controller; elements on power batteries; elements on telemetry; elements of flight plan software; elements on development environments for commercial drones.

LABORATORY Phase: CAD drawing execution of the drone frames; 3D printing of drone frames; bearing capacity measurements of various propeller-motor systems as a function of electrical absorption; programming of a fly controller; checks of the autonomy of the supply batteries; use tests of telemetry; implementation of flight plan processing software; use of development environments for commercial drones.

The scaffolding roles of situated learning:

a.Scaffolding figures identified within the school staff and their professionalism:

2 professors of Electronics and Industrial Plant Engineering

- 1 electronic engineer

- 1 doctor in physics

With teaching skills in: Electronic and electrotechnical systems, automatic systems and industrial plant engineering

b. Scaffolding figures identified outside the school context:

business professionals from partner P2 Aerodron di Parma, because of the following professionalities and technical competences

Founder & CEO of AERODRON. Electronical engineer, pilot	Sales manager and manager of public administration projects. Expert in technological innovation.	2 experienced UAV pilots, with a qualification recognized by ENAC. 1 pilot is also a geologist and an expert in photogrammetry and digital applications

P5 IISS "C.E. Gadda", Fornovo T. – Langhirano (Parma), Italy

http://www.itsosgadda.it/

It is a school with two branches, with both VET (Computer Technician, Economic Technician and professional diploma in Maintenance and Technical Assistance) study addresses and high school students (Scientific Applied Sciences option, both four-year and five-year).

Both branches worked on the project, with two complementary approaches.

1) Fornovo headquarters: Project Manager Prof. Luciano Amadasi

Reverse Engineering approach, chosen to focus the attention of teachers and learners on the effective understanding of the drone design and assembly aspects. Starting from a drone already

assembled, the students collaborated to take it apart, measure it, reprogram and reset the Arduino hardware and reassemble the basic components of the drone, finally trying to get it to take off.
The learning setting of work based learning is documented with a self-produced video, publicly available on the official YouTube channel of the D.E.L.T.A. Project at the following address https://www.youtube.com/watch?v=Kikbg0r7Myc

2) Langhirano headquarters: Project Manager Prof. Francesco Bolzoni
Focus on a physical-mechanical aspect linked to the sizing of the control circuit of a drone engine.
The learning setting of work based learning is documented with a self-produced video, publicly available on the official YouTube channel of the D.E.L.T.A. Project at the following address https://www.youtube.com/watch?v=_YtP6O-Uzeg
The activity involved the construction of a test bed to measure the thrust of brushless motors that will be used in the construction of the drone. In fact, sometimes the manufacturer does not provide this information; other times, since this parameter also depends on the type of propeller applied, it does not fall within the case reported by the manufacturer. The measurement of the engine thrust is fundamental both for the correct mechanical design of the drone and for the choice of the engine speed control device (ESC). The test bed consists of a low-friction roller guide: the dynamometer is integral with the fixed part of the guide; the motor and the relative propeller to be characterized is connected to the mobile end of the guide. The motor is powered by an adjustable power supply. An ammeter placed in series with the power supply circuit allows the current to be measured. When the supply voltage changes (and therefore the current) a different thrust is obtained by the motor-propeller block, measured in [g] by the dynamometer. Making the measurement for different supply values it is possible to obtain the characteristic of the motor-propeller in question (thrust data table). The measured values were reported in a spreadsheet.

Students involved:
Fornovo headquarters: n 15 students of the professional address in Maintenance and Technical Assistance
Langhirano headquarters: n 15 students of the professional address in Maintenance and Technical Assistance

Duration of the design phase: around 12 hours

Duration of the testing phase: about 30 hours

Learning objectives:

Mechanics	Design and dimensioning of the structure: correct application of the concepts of statics: module of resistance in peculiar structures (arms) Estimation of static and dynamic stresses concerning the same structures Adaptation of the structure to the electromechanical equipment necessary for the flight Material resistance. Static and dynamic stresses Sizing
Electronics & ICT	Know the composition and operation of the CPU Test the specific software (Arduino) PWM driving (pulse width modulation) Control of reactivity using a Kalman filter PID filter
Basic physics	Apply the laws of dynamics to the real situation of flight. Forces and accelerations. Angular momentum and acceleration. Preservation of angular momentum. Free body equation
Extension to other curricular subjects: Law English	Legal regulations relating to the use of UAVs (Unmanned Aerial Vehicles) - SAPR (Remote Piloted Aircraft Systems) in open and closed spaces National Authority in charge (ENAC - National Agency for Civil Aviation) European Regulations Technical terminology related to drone components

Organization of the learning environment according to the work-based-learning approach

In Class	Work-based learning At school
Theoretical lessons in mechanics, electronics, technology. Research on the Italian legislation concerning the RPAS. Meeting of the students interested in the first phases of the project with the P2 business partner AERODRON. Collaboration with AERODRON pilots for the study of the regulations concerning the SAPR Study of ENAC materials	Laboratory activity for assembly, programming, testing. Seminar conducted by experts on technical, regulatory and application aspects related to the drone. Safe flight of a professional drone.

The scaffolding roles of situated learning:

a.Scaffolding figures identified within the school staff and their professionalism:

Electronics teacher *Engineer, STEM teacher for the class involved in the experimentation.*	Electronics lab teacher *STEM teacher for the class involved in the experimentation.*	Mechanical technologies teacher *Engineer, STEM teacher for the class involved in the experimentation.*
Maintenance and technical assistance teacher. *Engineer, STEM teacher for the class involved in the experimentation.*	Technlogical lab teacher *STEM teacher for the class involved in the experimentation.*	Law teacher *Dealing with law and regulation about UAV's flight*
CAD Design teacher *Graphics teacher expert in CAD and 3D printing*	Maths teacher *STEM teacher for the class involved in the experimentation. Project*	ICT and systems & networks applications teacher *STEM teacher for the class involved in the*

	manager	*experimentation.*

b. Scaffolding figures identified outside the school context:

- professionals of the P2 business partner Aerodron of Parma, by virtue of the following professionalism and technical skills

Founder & CEO of AERODRON. Electronical engineer, pilot	Sales manager and manager of public administration projects. Expert in technological innovation.	2 experienced UAV pilots, with a qualification recognized by ENAC. 1 pilot is also a geologist and an expert in photogrammetry and digital applications

P6 Centro Público Integrado de Formación Professional "Corona de Aragon", Zaragoza, Spain

https://www.cpicorona.es/web/

This is a VET institute that offers a professional two-year course as the last cycle of secondary education, accessible to secondary school graduates (aged 16 and over). The institute also welcomes workers who wish to retrain professionally or add / update their technical skills, in day or evening mode. CPIFP offers, among others, the following study addresses:

- Industrial Mechatronics
- Production planning in mechanical manufacturing
- Electrotechnical and automated systems
- Civil Construction
- Environmental Chemistry
-Industrial chemistry

For the IO1 experimentation, the study courses in Industrial Mechatronics and Mechanical Manufacturing were involved, which tested two different approaches to the engineering study of the drone: an attempt was made to design and draw in CAD and subsequently construct it using the supplied 3D printer , and finally to assemble, the external supporting structure (chassis) of a quadricopter in PLA. The drone was subsequently equipped with brushless rotors and battery, with electronic circuit, and a flight test was attempted which however did not perform according to the desired standards. As a second approach, always inspired by Reverse Engineering, pre-designed and partially assembled parts and components were purchased, to disassemble, disassemble them, study them and then reassemble and test the drone.

The learning setting of work based learning is documented with a self-produced video, publicly available on the official YouTube channel of the D.E.L.T.A. Project at the following address https://www.youtube.com/watch?v=l30cAhUUzE0

Students involved:

About 15 students from the Course in Industrial Mechatronics and Mechanical Design

Duration of the design phase: 15 hours

Duration of the testing phase: 15 hours

Critical issues & key competences identified in the drone design and engineering process
Mechanical systems
Hydraulic and pneumatic systems
Electrical and electronic systems
Equipment transactions
Manufacturing processes
Graphic representation of mechatronic systems
Configuration of mechatronic systems
Process and management of maintenance and quality
Systems integration
Simulation of mechatronic systems
Industrial mechatronics projects
Professional Training and Accompaniment / Tutoring
Business & Entrepreneurial Initiative
Training on the Job

Learning objectives

Criticalities & key processes	**Learning Objectives**	**Outcomes (skills)**
Elements relating to machinery	Know the mechanism of the different elements and machines and their interactions	Elements of mechanical systems (gears, cams)
	Design the mechanisms according to the movements required based on the technical specifications	Material resistance
	Make the correct choice of materials according to technical and economic factors	Material properties. Fe-C diagrams. Thermal treatments
	Dynamic and kinetic calculation of mechanisms	Speed, torque (torque), power and performance
Productive process	Knowledge of the different machinery and equipment useful for the mechanical production process. Quality and performance of materials and processes with reference to the output product.	Mechanical tools: lathe, milling cutter, drill, electroerosion machine, grinder
	Establish the correct sequence of operations to be performed for the production of a mechanical piece	Correct use of spreadsheets to support production
	Make a correct choice of materials based on technical and economic factors	Operability and behavioral rules relating to the production process
	Dimensional and geometric control	Use of measurement and verification tools: gauge and thickness gauge, micrometer
	Operate the machinery in the laboratory	Perform dimensioning operations with

		electric and digital instruments (chip starting tools)
Graphic representation of mechatronic systems	Drawing of mechanical elements (in section, with different cuts and dimensions)	Representative systems in natural size, in quarters, and in scale
	Representation of dimensional and geometric tolerances	Symbols: parallelism, perpendicularity, concentricity
	Design documentation through the use of CAD systems	Libraries and tools for mechanical design
Mechanical systems	Assembly and disassembly of mechanical elements thanks to the interpretation of technical drawings and diagrams	Removable joints (screws) and fixed (rivets and adhesives)
	Diagnostic (Troubleshooting) techniques in case of incorrect assembly or defective parts	Predictive and preventive maintenance of drones
	Develop a specific maintenance plan for drones	Items subject to maintenance. Pareto Laws and Bath Curves. Causes of failure
Interdisciplinary aspects	Safety and risk prevention	-
	Cooperative Learning	
	Vision and understanding of the phases of	
	design, production and assembly of a mechanical product	

Organization of the learning environment according to the work-based-learning approach

The environment and school laboratories, with a strong vocational vocation, are entirely designed according to the logic of work-based learning. The theoretical and preparatory lessons are always integrated from the conceptual phase with practical and laboratory activities, aimed at the design and production of physical and concrete artifacts.

Tools and equipment: 3D design software, 3D printer, machine tools. Materials: PLA and carbon fiber filaments, electronic circuits and Arduino boards, metals of various nature and shape (especially aluminum).

The scaffolding roles of situated learning:

a.scaffolding figures identified within the school staff and their professionalism:

A professor of mechanical and industrial engineering, expert coordinator of innovation projects and organization of work based learning sets, both in the upper secondary cycle and at the University of Zaragoza

CAD design expert teachers

Expert lecturer in 3D printing

Certified UAV pilot for vehicles up to 5 kg

b. Scaffolding figures identified outside the school context:

1 professional of the P7 business partner AITIIP of Zaragoza, with experience in co-designing learning environments that simulate industrial design in the automotive and aeronautical fields

1 tutor of the University of Zaragoza, expert in mechanical engineering projects and industrial applications, with experience in designing learning environments according to the work-based learning de approach by virtue of the following professionalism and technical skills

P8 Liceul Teoretic de Informatica "Grigore Moisil", Iasi, Romania

http://www.liis.ro/

It is a school of excellence in the field of technical studies in the field of information technology, systems engineering and programming. It is CISCO Academy's certified headquarters and every school year around a hundred graduates immediately enter the labor market of the Romanian Moldavian region, a constantly growing technological and IT hub.

Being an institution that is highly specialized in computer science, LIIS does not offer the disciplines related to mechanical design or mechanical processing techniques within its own educational program. However, an afternoon club called "Eurodrone" was designed by the project team, which was configured as an optional extra-curricular activity, optional for interested students on a voluntary basis, to which around 30 students joined (with a fairly balanced proportion). between males and females).

In consideration of the predominantly theoretical aspect that characterizes the LIIS institute, we chose to follow the Reverse Engineering approach: mechanical components, electronic circuits and batteries were purchased to allow the reconstruction of a harmless drone according to the work based approach , in two ways:

- Workshop settings for the study, disassembly and assembly of the inoffensive drone as a physical object, under the guidance of business-oriented partner Ludor Engineering as a scaffolder, thanks to the skills in engineering, applications and industry
- Setting design and 3D modeling of the inoffensive drone, starting from procedures explained and carried out, publicly available on open repositories like Instructables.com

Thanks to the students' solid computer skills, it was possible to design, design and size parts of the load-bearing structure of the inoffensive drone (upper cap, support base, arms and propellers) using free programs for educational purposes such as Tinkercad online on a cloud platform, 3D Builder and Sketch Up. The model was subsequently printed in 3D using PLA filaments, taking examples already developed and described online from articles such as "Make an quadcopter with 3D printing" https://www.instructables.com/id/Make-an-H- Quadcopter-with-3D-printing /

The learning setting of work based learning is documented with a self-produced video, publicly available on the official YouTube channel of the D.E.L.T.A. Project at the following address https://www.youtube.com/watch?v=i_duHb2MV3I

A second in-depth video on the contents and products of the trial, as well as on the educational organization, is available on the same YouTube channel at the following address https://www.youtube.com/watch?v=iEw7tqzUCag

Students involved:

Approximately 30 students on a voluntary basis, generally selected among those most interested in exploring issues of industrial application, engineering and automotive, as well as 3D modeling

Duration of the design phase: 30h (6 weeks x 5h)

Duration of the experimental phase: 30h 30h (6 weeks x 5h)

Learning objectives

a.Educational objectives that can be linked to the curriculum STEM subjects:

Elements of mechanical design

Elements of Aerodynamics

Elements of Electronics

Computer science and 3D programming

b. Extra curricular knowledge and skills that contribute to the outgoing professional skills of students:

Design and design of inoffensive drones

Assembly techniques for inoffensive drones

Operation and management of the in-flight harmless drone

Manage, collect and interpret data on the ground

The scaffolding roles of situated learning:

a.Scaffolding figures identified within the school staff and their professionalism:

1 English language teacher, Project coordinator and responsible for the pedagogical organization of the experimentation, implementation and verification of the learning objectives, as well as the management of relations with the P1 Coordinator Cisita Parma for the monitoring of the project phases

1 physics teacher

1 IT teacher with skills in 3D modeling in CAD and mechanical design

b. Scaffolding figures identified outside the school context:

PhD Ing. Doru Cantemir, owner of P9 Ludor Engineering, expert in technological applications for educational and industrial purposes, 3D modeling, rapid prototyping and additive manufacturing.

II. 2 Physical products of the experimentation

IO1 consists of 3 distinct and complementary partes:

1) this document, which aims to provide guidelines for the replicability and transferability of the experimentation to another educational and training context, of any level, order and level

2) 6 videos documenting the work-based setting of the experimentation (2 videos for P5 Gadda and 1 video for each of the 4 VET school P3 Ferrari, P4 Berenini, P6 CPIFP and P8 LIIS), publicly available on the YouTube channel of the D.E.L.T.A. Project https://www.youtube.com/channel/UCoLeV-LZzAYRj7pr1wckprA

3) teaching materials useful for the replicability of experimentation such as presentations with technical specifications relating to the technologies adopted in IO1. The materials are publicly available at the shared link https://drive.google.com/open?id=1XeLrlmzIxC2uzl7vclCn77cr3jhwkqVo

In the folder named IO1 - Engineering it is possible to find:

to. The proposal of P4 Berenini for the identification of teaching approaches for the application of drones to the study of engineering

b. The .stl files to redesign in CAD parts and components of the drone structure, according to the approach of P6 CPIFP and P8 LIIS

Final note

The Intellectual Outputs and the results of the project are released according to the international license Creative Commons Share Alike 4.0. The products are available for reuse, transfer and modification through adaptation, in the form of an Open Teaching Resource (OER - Open Educational Resources): any user interested in OER can download, modify and disseminate the Intellectual Output for non-commercial purposes, provided that credit is given to the author Cisita Parma scarl and provided that the new OER is shared according to the same license terms.

The project resources can be consulted and downloaded free of charge at the following channels:

Official multilingual website of D.E.L.T.A. project:
www.deltaproject.net
(Resources available in Italian, English, Spanish, Romanian and Portuguese)

Official YouTube Channel of Delta Project, where it is possible to view 30 videos dedicated to the work-based learning setting: each of the 5 partner schools has self-produced a video documenting the laboratory and experiential environment in which the students have materially produced or designed and studied drone components , for each of the 5 Intellectual Outputs envisaged (P5 Gadda produced 2 videos * Output, for each of its two Fornovo and Langhirano locations.

Shared folder on su Google Drive belonging to D.E.L.T.A. project account deltaeuproject@gmail.com , from which it is possible to download the didactic materials for each Intellectual Output, designed for replicability and transferability, at the address https://drive.google.com/open?id=1XeLrlmzIxC2uzl7vclCn77cr3jhwkqVo

Institutional website of Cisita Parma scarl, Coordinator of D.E.L.T.A. project
https://www.cisita.parma.it/cisita/progetti-internazionali/progetto-eramus-ka2-delta/
(Resources available in Italian, English, Spanish, Romanian and Portuguese)

National and international public repositories for OER – Open Educational Resources sharing:

OER Commons, digital library in English dedicated specifically to Open Educational Resources https://www.oercommons.org/

TES, British portal for free sharing of multidisciplinary teaching material, https://www.tes.com/

Alexandrianet, italiano portal for free sharing of multidisciplinary teaching material, http://www.alexandrianet.it/htdocs/

Further social updates are published onto:

Official D.E.L.T.A. project Facebook page @deltaeuproject https://www.facebook.com/deltaeuproject/

Institutional digital channels of the Coordinatore Cisita Parma scarl:

Facebook https://www.facebook.com/CisitaPr/

Twitter https://twitter.com/CisitaPr

LinkedIn https://www.linkedin.com/company/cisita-parma-srl/