DRONES4VET

Co-funded by
the European Union

Handbook for educators

Drones for construction, A comprehensive guide to effective teaching with Drones4VET modules

2024

DRONES4VET PROJECT

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1. Introduction

Drones4VET addresses an identified gap in the training offered within the construction-related activities. To date, the education and training offer has solely focused on the mastering of the traditional techniques, mainly based in the manual and on-site surveillance, inspection and assessment of civil works, buildings and constructions sites.

This approach to training has not in essence changed in the past decades. The advent of the new technologies, both from the point of view of the software/applications and the hardware/devices, has fundamentally altered the dynamics of the sector.

The project consists in the development of 10 training modules for the use of drones in construction. It is funded by the Erasmus+ European Union Programme under the reference N° 2021-1-ES01-KA220-VET-000033094.

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1.2 Purpose of the Handbook

The content enables the teacher/trainer to develop course materials, based on the 10 Drones4VET modules, considering the target audience, learning objectives, and feasible methodology, including didactic reduction. References to individual modules, along with brief content descriptions, would be helpful in this regard.

Especially for different target groups (construction trainers/craftsmen), the handbook describes or explains the technology to be conveyed in all aspects in a simple (understandable) and "as concise as possible" manner.

The primary aim of this handbook is to empower teachers and trainers in the field, equipping them with the necessary tools to proficiently develop course materials tailored to diverse target audiences. By providing insights into the intricacies of educational planning, the content serves as a guide for instructors to strategically align their teaching strategies with the unique needs of learners. This involves a meticulous consideration of the target audience, learning objectives, and the adoption of feasible methodologies, with a specific focus on didactic reduction to enhance the overall effectiveness of the educational process.

The handbook is designed to offer practical assistance, offering references to individual Drones4VET modules within the course. These references, accompanied by brief content descriptions, serve as valuable resources for instructors seeking to customize their teaching materials. By incorporating this feature, the handbook aims to facilitate a streamlined and efficient course development process, ensuring that educators can easily navigate through the content and make informed decisions regarding the selection and presentation of learning materials.

Furthermore, the handbook recognizes the diversity of target groups within the educational landscape, with a special emphasis on construction trainers and craftsmen. For these specific audiences, the content goes beyond a mere description of technology; it delves into a comprehensive explanation of the subject matter in a simple and easily understandable manner. The overarching goal is to present technical concepts in a manner that is both accessible and concise, catering to the unique learning styles and requirements of individuals within these professions. This ensures that the conveyed technology is not only comprehensible but also highly relevant and applicable to the practical aspects of their work, ultimately enhancing the overall educational experience for both teachers and learners alike.

1.3 General Information and needed skills (trainer level)

Figure 1: Trainer with drone, example (AI generated - Adobe Firefly)

Being a trainer for drone use requires a combination of technical knowledge, teaching skills, and industry expertise. Here's a list of essential skills:

- **Technical Proficiency:** A deep understanding of drone technology, including components, operation, maintenance, and troubleshooting. This includes knowledge of different types of drones (fixed-wing, multirotor, hybrid), their capabilities, and limitations.
- **Regulatory Knowledge:** Familiarity with local and international drone regulations and laws. This includes understanding airspace restrictions, licensing requirements, safety protocols and insurance.
- **Flight Experience:** Practical experience in flying drones across various environments and conditions. Trainers should be adept at piloting drones safely and effectively, demonstrating manoeuvres and techniques to trainees.
- **Risk Management:** Ability to assess and mitigate risks associated with drone operations. This includes understanding hazards such as weather conditions, obstacles, and potential interference with other aircraft.
- **Communication Skills:** Clear and effective communication is essential for conveying technical information and instructions to trainees. Trainers should be able to explain complex concepts in a concise and understandable manner.
- **Instructional Design:** Skill in designing training programs and materials tailored to different skill levels and learning styles. This involves creating lesson plans, presentations, and hands-on activities to reach learning objectives.
- **Safety Consciousness:** Prioritizing safety is paramount in drone operations. Trainers should instill a safety-first mindset in trainees, emphasizing the importance of following protocols and best practices to prevent accidents and injuries.

2. Overview of modules and Lesson planning

2.1 Modules and learning outcomes

Table 1: Overview of the modules

Level	No	Icon	Module Name
Basic	1		DRONE REGULATION
	2		FLIGHT PLANNING AND REPORTING
	3		DRONE DYNAMICS AND MAINTENANCE
	4		FLIGHT SIMULATOR
	5		FLIGHT PRACTICE
Advanced	6		GEOLOCATION
	7		PHOTOGRAMMETRY
	8		THERMOGRAPHY
	9		LIDAR
	10		PICTURES FOR EXPERTISE

Table 2: Modules and Learing Outcomes

No	Module Name	Objective	Learning Outcomes	Suggested Delivery/Assessment
1	DRONE REGULATION 	This module covers the information the learner will require to gain a basic understanding of the relevant UAS regulations governing the safe operation of drones in Europe. It will identify and describe the relevant drone categories (Open, Specific & Certified) to which a particular drone operation relates in accordance with UAS Regulations. Identify key terminology used within the UAS regulations with respect to the safe operation of drones in Europe. Finally, it will help to develop an understanding of the types of risk assessment methodologies (SORA, PDRA, etc) and mitigation measures that may be employed to ensure drone operations may be carried out safely.	**1** The learner will gain knowledge about European level Governing body. **2** Gain knowledge about Open, Specific and Certified Categories. **3** Understand and differentiate between different operation scenarios. **4** Gain understanding of UAV operators responsibilities and liabilities.	**Delivery:** In-class or online module delivery **Assessment:** Closed book exam/test of module related content/knowledge
2	FLIGHT PLANNING AND REPORTING 	This module describes the checklists to be followed during the various phases of drone use. For the preparation of an operation with UAS, as it is done with any other type of aircraft, a series of steps and actions must be carried out before, during and after the flight in which checklists are normally used. In this checklist, the person in charge of operations and/or the drone pilot checks the indicated tasks in order. As they are completed, they are marked so that you can be certain that you have taken all the precautions described. This allows you to keep accurate control and confirm that the necessary tasks for the operation have been carried out, particularly in the event of legal action. An example of "mission sheet" for the open category is presented. After these general use check lists, the drone settings will be described to show an example of complete set up operation.	**1** The learner will gain knowledge about relevant drone flight regulations and safety protocols **2 plan drone flights, such as route planning** **3** The learner will be able to compile comprehensive flight reports and analyse flight data	**Delivery:** In-class **Assessment:** multiple-choice questionnaire or open questions for flight planning: hands-on activities / report as homework

3	DRONE DYNAMICS AND MAINTENANCE 	This module is divided in two main parts: Chapters 1, 2 and 3: essential knowledge about how the drone uses aerodynamic forces to fly, with simple flight mechanics information. Followed by a description of the role and function of a drone's various flight components. Finally the general operation of the joystick. Chapters 5 and 6: how to maintain the drone in good condition for flying, and record the maintenance operations according to a professional plan. The module focuses on the multirotor drone, destined to basic level pilots. Physics is not covered, only practical questions.	**1** Gain knowledge about the way drones fly **2** know the components of a quadcopter drone system **3** manage a maintenance program	**Delivery:** in class **Assessment:** multiple-choice questionnaire or open questions for maintenance: hands-on activities
4	FLIGHT SIMULATOR 	Using a flight simulator to learn how to fly is commonly made, particularly by professional pilots. This module presents you the advantages of using a simulator and some types of possible learning situations. Then after listing different simulators, the use of a flight simulator is developed.	**1** knowledge of different simulators **2** develop and refine their skills in executing advanced flight maneuvers **3** apply their skills to realistic flight scenarios	**Delivery:** In-Class (computer room) **Assessment:** Complete simulated flight missions
5	FLIGHT PRACTICE 	This module allows you to take control of the drone from a beginner's level to a first step allowing you to fly in the open category sub-category A2 where a self-training flight course must be done. A secured flight zone is proposed, and all the exercises take place in this zone. The flights are purely utilitarian in nature, with a view to taking manual photographs: - Photogrammetry - Expertise of constructions - Thermography - Lidar NB: The module is written for a teacher who explains to his students, but a student alone can practice by following the module.	**1** know the joystick functions **2** mastering manual drone control **3** mastering drone piloting for photogrammetry, lidar, thermography and building expertise	**Delivery:** In class: prepare mission form On secured field : fly **Assessment:** hands-on activities, Rate skills from 1 to 4 (1 beginner, 4 advanced)

6	GEOLOCATION 	This module allows you to understand the coordinate systems used to locate points on earth. It explains how a map is made in a projection system. It allows you to geolocate terrestrial observations. In order to locate information on the earth's surface, it is necessary to use a positioning and mapping system. For this, geodesy notions are necessary, such as - the definition of a geodetic reference frame (ellipsoid, meridian of origin) - the choice of a system of projections and coordinates (geographic and planar) - the choice of a height reference system (geoid). The module explains also how a Global Navigation Satellite System ("GPS") works and how to get a centimetric accuracy thanks to RTK. At the end you'll see how to position targets on the field to geolocate your drone observations.	**1** gain knowledge about terrestrial geolocation systems **2** gain knowledge about national geolocation systems **3** know the use of a GNSS for geolocation of drone surveys	**Delivery:** In class most of the time Outside to show GNSS with RTK **Assessment:** Multiple-choice questionnaire or open questions
7	PHOTOGRAMMETRY 	This module allows first to understand what photogrammetry is, then to see the techniques to achieve automatic or manual flights of drones for this activity and finally to process the images to obtain 3D models and exploit them. Basic level module for the use of drones in construction, considering that all the knowledge set out here is essential.	**1** gain knowledge about drone use for photogrammetric flights **2** master the processing of pictures to obtain a 3D model **3** mastering the process to exploit a 3D model	**Delivery:** In class for processing On the field for photography with the drone **Assessment:** multiple-choice questionnaire or model result (shape, scale...)

8	THERMOGRAPHY 	This module allows you to understand the thermographic analysis with drones. The objectives for thermography with drones include identifying anomalies, assessing conditions, improving energy efficiency, and monitoring the environment. These applications offer a non-intrusive, cost-effective, and efficient means of capturing thermal data from aerial perspectives. Desired skills - Description of the parts of the building exposed to thermal effect o Envelope: Facades and roofs o Pipelines of the technical building equipment o Solar system / Photovoltaic - Identification of weak points that influence the thermal / energy behaviour of the building, o Envelope o Air tightness check o Solar system / Photovoltaic - Analysis of thermographic images - Equipment / Hardware o UAS o Cameras - Camera configuration o Software - Preparation of the documentation / reports	**1** gain knowledge about drone use for thermography **2** Learner will be able to analyse and assess thermographic images to identify anomalies in buildings, pipelines and solar systems. **3** Learner will be proficient in preparing a comprehensive documentation and report based on the thermographic analysis findings.	**Delivery:** In-class or online module delivery **Assessment:** Theoretical part: Closed book exam/test of module related content/knowledge Practical part: A report documenting the analysis, findings and recommendations for improving energy efficiency on a selected building or structure
9	LIDAR 	This module will introduce the learner to LiDAR and how this remote sensing technology may be used in conjunction with UAS to capture filed data. The key terminology with regards to LIDAR scanning is identified as is the primary methods as to how a LiDAR scan may be carried out. An illustrated example of the steps involved in successfully carrying out a LiDAR scan using a UAS is explained and how the resulting data may be processed. Finally, some examples of the many applications within the construction industry for which this technology may be used in conjunction with UAS are discussed.	**1** Learner will gain understanding of definition of LIDAR. **2** Expertise of different use of UAV based LIDAR scanning in construction. **3** Develop knowledge in different LIDAR types and their utilisation for specific type of UAV missions.	**Delivery:** Theory delivery in-class or online. LIDAR capture – in-class/field testing LIDAR data processing – in class/ or online delivery **Assessment:** Closed book exam on theory contained within the module. Practical exam in collection and processing of LIDAR data

10	PICTURES FOR EXPERTISE 	This module, which complements the practical flying module, gives a few tips on how to take photographs that are useful for inspecting civil engineering structures. In this activity, unlike photogrammetry where we generally work in full automatic, it is necessary to take "real" photos that are detailed, sharp, bright, localised and informative. You also need to know how to identify sensitive areas on structures. This module covers the main principles of photography, followed by advices on how to take and present photographs.	**1** gain knowledge about photography **2** choose the right angles and settings to produce usable shots **3** create professional deliverables	**Delivery:** On the field for photos, secured area In class for deliverable **Assessment:** On the field: drone proximity ability and choice of sight Rate the deliverable (photo quality, angles, zoom...)

2.2 Structured Lesson Plan

In the previous chapter, the possible modules and their learning outcomes are defined. However, for the compilation of a customized program, it is relevant to arrange the modules according to the program's objectives. The structure can vary depending on the educational institution, the available resources (trainer competencies), and the target audience.

> However, it is recommended that at least the basic modules (1 to 3) be completed before moving on to the advanced modules (5-10). The basic modules thus should serve as a prerequisite for modules 5-10.

Duration
Similarly, no specific duration can be prescribed as it also depends on the target audience. However, based on experience and as general guidelines, it can be assumed that the ***basic modules typically require an average of 0.5 to 1 day each, while the advanced modules require more than 1 day***. Planning the duration should follow the ECTS system, as it encompasses the entire workload.

The **workload** comprises all learning activities that are part of a study program and are assessed through performance evaluation. These include:

- Attendance at lectures or classes
- Internships
- Self-study (library work or work at home)
- Exam preparation
- Exam

An **ECTS credit** corresponds to **25** real **hours** of 60 minutes each of actual workload for the student.

The following table shows a simple example of a potential training program. The time estimates provided refer solely to instructional time (excluding pre- and post-preparation and practical components).

Table 3: Example of a program structure

No	Icon	Module Name	Setting	Duration of lecture / ECTS
1		DRONE REGULATION	Classroom	4 h / 0,25
2		FLIGHT PLANNING AND REPORTING	Classroom	4 h / 0,25
3		DRONE DYNAMICS AND MAINTENANCE	Classroom / lab	8 h / 0,50
4		FLIGHT SIMULATOR	Classroom	12 h / 0,75
5		FLIGHT PRACTICE	Classroom / Outdoor area	12 h / 0,75
Written exam (1-3) / Test (4) / Report of practice (5)				**40 h / 2,50**
6		GEOLOCATION	Classroom / Outdoor area	12 h / 0,75
7		PHOTOGRAMMETRY	Classroom / Outdoor area	12 h / 0,75
8		THERMOGRAPHY	Classroom / Outdoor area	12 h / 0,75
9		LIDAR	Classroom / Outdoor area	12 h / 0,75
10		PICTURES FOR EXPERTISE	Classroom / Outdoor area	8 h / 0,50
Report of case studies (6, 7, 8, 9, 10)				**56 h / 3,50**
Sum of the program				**96 h / 6,00**

2.3 Integrating Case studies Applications

The case studies primarily serve the advanced-level modules. They involve depicting various scenarios on real objects. **Damage scenarios can also be temporarily simulated as fake.** (For example, by using attached images). This allows for the identification of damage patterns such as cracks, discoloration, and structural shifts. This approach would be beneficial for Module 10.

Figure 2: Typical damages on facades (https://www.zukunft-bau.at/bauschadensberichte)

Figure 3: Typical damages on roofs (www.bauder.at / www.hausjournal.at)

3. Creating a Positive Learning Environment

3.1 Classroom Setup and Organization

Depending on the module, different classroom setup can be used, but it is essential to have:

- A computer for the teacher
  - linked to the internet
  - Powerful enough to run 3D and imagery software
  - With at last 100 GB free memory to store documents and particularly photos
  - with a video projector and a screen
  - have the required software depending on the modules
  - a network or a cloud storage to dispatch the photos, scans, tests and to retrieve the work for assessment
  - eventually: a software to display the student's computer screen, and even take hand on their mouse to help them.
- A computer for each student, same specifications (except projector).
- A whiteboard.

The classroom can be in a U shape, with the computers displays visible from the centre, thus the trainer can see if everybody is following the rhythm of the lesson. But a "student view" software can replace this positioning.
Concerning the modules, in addition to the above list, here are a few tips on how to run your course and the specific resources you'll need.

Module 1-Drone regulation:

- Prepare your access to the EASA website, drone part.
- Prepare your access to your national drone test website (pilots certification).
- Take your drone to show its identification plate and emission.
- Get your MANEX.

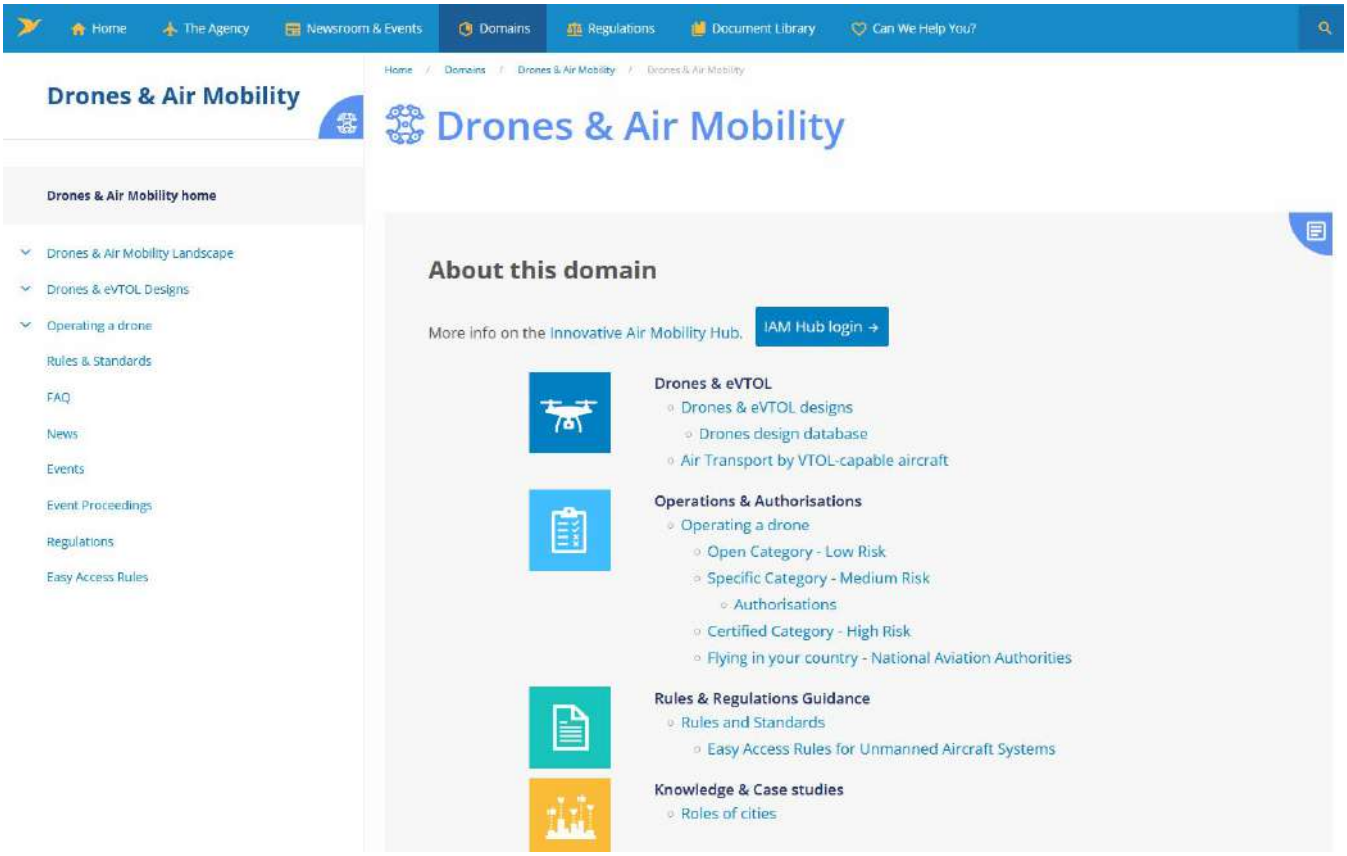

Figure 4: EASA website - the "drones & air mobility" page is fine to begin and then go to the different topics (EASA)

Module 2-Flight planning and reporting:

- Prepare 1 drone mission form for each student, paper or electronic.
- Prepare 1 flight log template for the students, to record the flights.
- Have at last 1 drone to practise the drone check procedure (pre-flight checklist).
- Connect to a METAR and TAF national website with the code of the nearest airport to be ready to show it to your students (f.e. https://fr.allmetsat.com or android apps UAV forecast or Aviaweather).
- Connect to a national graphic weather website to show the wind force, the cloud covering in simple images.
- Connect to the national flight accident declaration website (relative to EU regulation 376/2014) or the national flight incident declaration sheet (CRESUS2022 in France for instance).
- Practising the "command settings" via the remote controls of the drones.
- Prepare a link your local or national authorization procedure webpage (advanced flights in specific category).

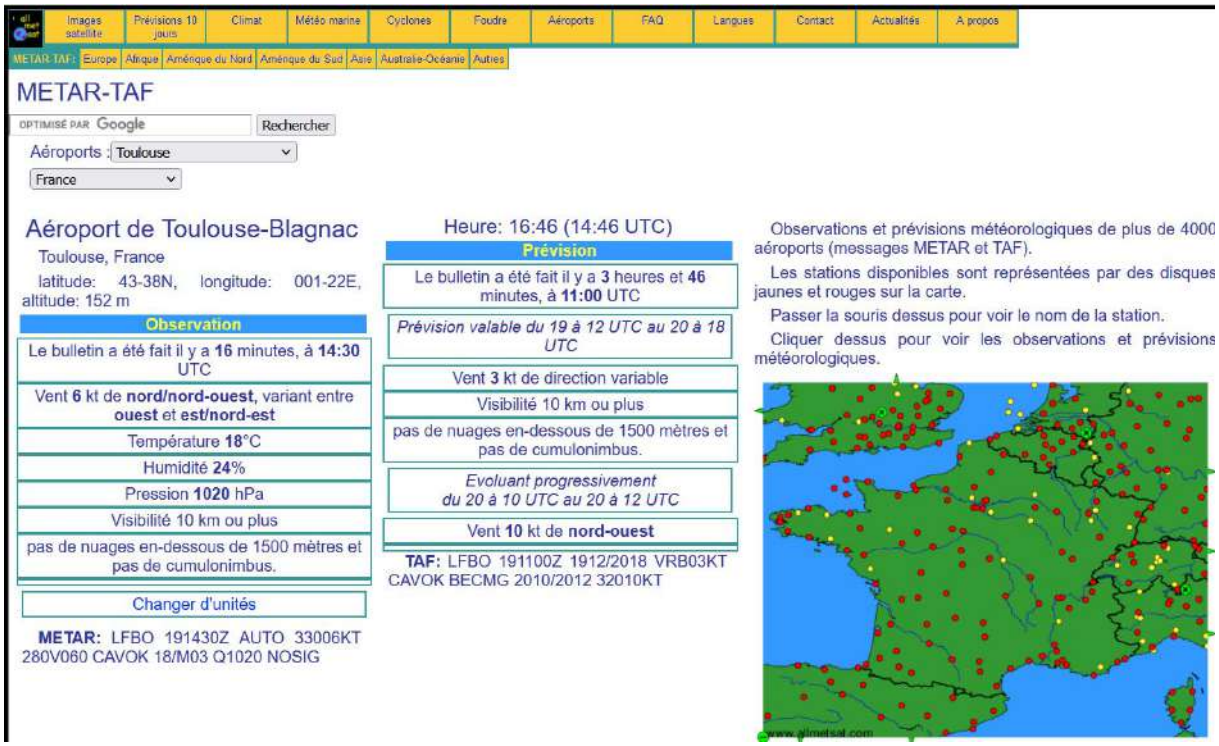

Figure 5: https://fr.allmetsat.com this website displays the METAR and TAF messages in both clear and original version - all Europe covered in different languages

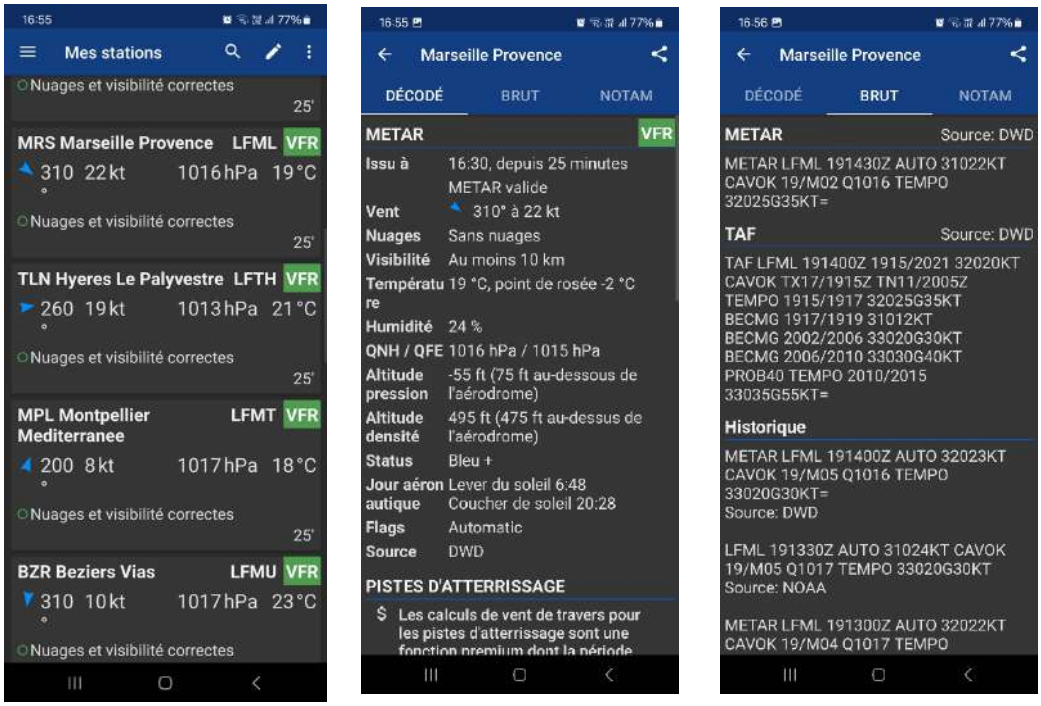

Figure 6: android app : "Avia Weather" does the same, and you can also get NOTAM (pay option)

Module 3-drone dynamics and maintenance

- Two possibilities:
  - You have a drone you can disassemble to show the components,
  - You collect pictures on the internet to show other examples than in the module.
- Have 1 drone to show the movements, the batteries...
- It is possible to use a smartphone with an app showing the sensors: magnetometer, compass, acceleration, yaw, roll, pitch... (for instance on android "GPS status" and select <<sensors diagnostics>> and all the sensors with their values appear).
- Have a maintenance record book ready.

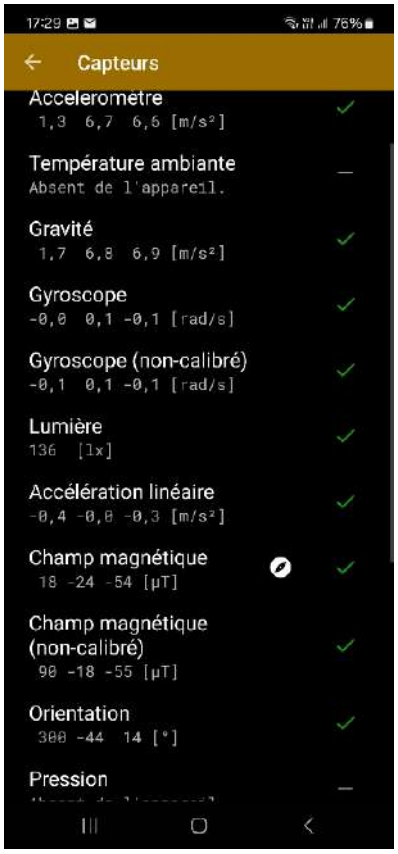

Figure 7: Android app: "GPS Status" choose the sensors page, it displays all your active sensors with their values. students can understand what an accelerometer is for instance

Module 4-Flight simulator

- Download the flight sim you wish to use, install it in the trainer's computer and check all the installation setup to be able to help the students with their own computer or install it on all the computers of the classroom.
- Have a real drone to show off the attitudes.
- Have a remote control, linked to the software for each student.

Module 5-Flight practice

- Select and prepare your flight place (see below "outdoor sessions").
- Prepare a flight mission form for each student.
- Connect to a METAR and TAF website (see above mod. 2). Get the UAV Forecast application installed (or else).

- Explain the guidelines in the classroom and prepare the flight with the flight mission form, each student should fill his own form.

- Program the geo-cage on all the remote control or on the students smartphones if they are used to pilot the drone, the students must be able to program it themselves but it is mandatory to the trainer to check. The dimensions depend on your flight place, category of drone, type of flight.
- Get all the necessary cones and take-off marks (see below "outdoor sessions").

Figure 8: geo-cage programming in a remote control. Don't hesitate to set low values at the beginning (Parrot)

Module 6-Geolocation

- Connect to your national geographical and geodesic website to show the benchmarks and legal coordinates.
- Have some kind of a globe to show the earth, meridians, parallels...
- Install the "GPS status" app in your smartphone to show the coordinates, accuracy, and the position of GNSS satellites.
- A large sheet of paper can show the projections from the globe.
- An orange skin is useful to show how difficult it is to flatten a sphere (see below).
- Have some ground targets.
- Prepare your GNSS receiver and its RTK link.
- The pictures below show an example of experiment for cylindrical projections.

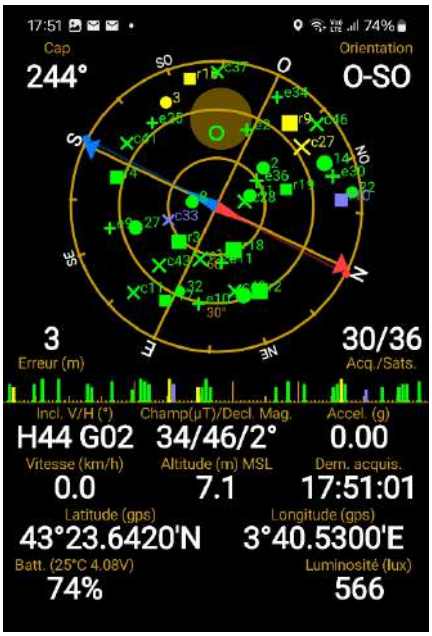

Figure 9 Android app "GPS Status" screen

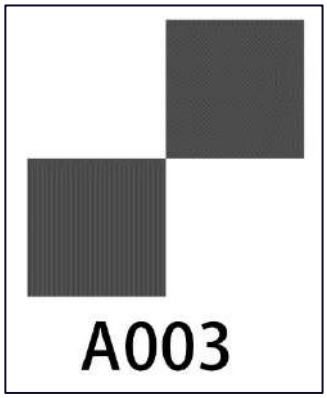

Figure 10: ground target with number (LePont.com)

Figure 11: an orange skin helps to show it is difficult to flatten a sphere

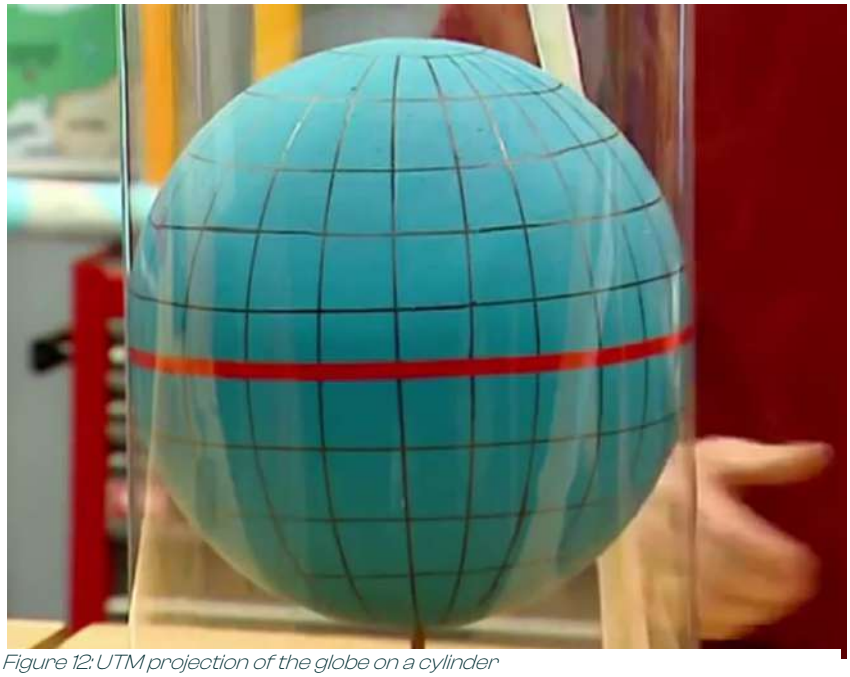

Figure 12: UTM projection of the globe on a cylinder

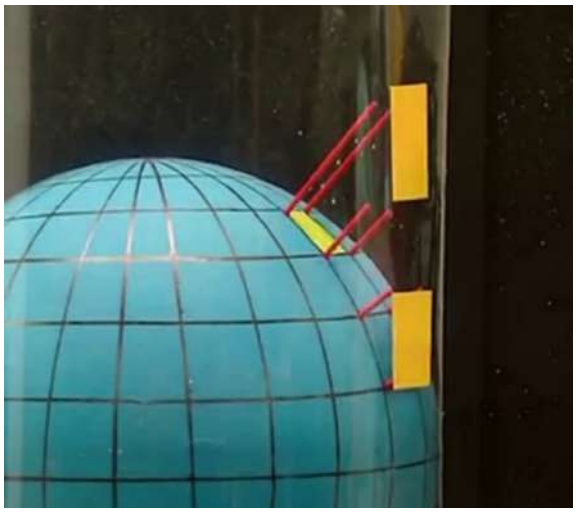

Figure 13: distance distortion due to the cylindric UTM projection (France 3 "C'est pas sorcier")

Module 7-Photogrammetry

- A quick modelling with a smartphone is a good beginning to show the capacities of photogrammetry, install the app "Polycam" and make a model by turning around an object on a table, the students can experiment it also (the result is not always very good but it shows what photogrammetry is... for free).
- It is possible to record a video of a programmed flight or go outdoor to make one, so as for a façade, to show how the pictures are taken by the drone.
- Save on the network of the school all the photos to be used for the process; or prepare a USB stick with the photos to share with the students.
- If you have a small project, such as 50 photos, and good computers, it is possible to make the process totally with the calculations. Remember to use only the local drives (SSD is best) to save the photos and models, not a cloud or a network drive or a USB drive because they are too slow and unreliable.
- If your project is bigger, and/or your computers just normal or slow, then **Pre-compute** all the steps and record them with your software: give a different name to all steps and record them one after the other. The students will not have to wait for the long calculations, you launch the computing, stop it after a few minutes, and the students download the pre-recorded results.

Figure 14: Polycam model of an architect's real model (Julie Lequeux-Audran) on a table in the classroom (extract from the video that can be generated)

Module 8-Thermography

- Check if the colours displayed by your video-projector are legible
- In the classroom it can be interesting to have a thermographic camera for easy learning.
- The drone used outdoor can be used inside, hand-held.
- See "outdoor sessions".
- have your photos recorded and ready to share by the network or a USB stick.

Module 9-LIDAR

- An Apple iphone pro has an integrated lidar that can be useful to show the capabitities of such a device, like in "photogrammetry" with the Polycam app
- A stand-alone 3D scanner on a tripod can be set to explain the scanning process and the limits of the method
- The LIDAR drone has to be physically present in the classroom in order to understand the limits of its use (size, shape, noise...) and the scan angles of the system.
- It is possible to hand-hold the drone in the classroom or a corridor to show how the points are scanned.
- All the point cloud must be ready to download by the students.
- Pre-record all the steps of your process with different names in order to give them to the students to correct their errors or to speed up the lesson by avoiding long computation time.
    -

Module 10-Pictures for expertise

- Find a place in your building where a few problems can be found for practise (beware to uninvolved persons security).
- It is possible to place photo prints of cracks or other structural problems on a healthy structure to simulate a survey.
- See “outdoor sessions” .
- Prepare at least 1 photography to work on and its enhancement with a photo editor.
- The drone can be used hand-held in a classroom to show different problems, (backlight, over or under exposure, motion blur...) or the best angles to take a photograph.

3.2 Indoor and Outdoor sessions

Indoor

BEFORE any flight, we recommend to teach modules 1 + 2 + 3 (regulations, planning, dynamics) and as an assessment pass the A1/A3 on the official website of your country.
Learners will be more committed to their training if they already have a first diploma in their pocket, which gives them a sense of responsibility, and you'll be better insured in the event of an incident in the field, so you can't be blamed for getting uninformed people to fly.
Note that they can also pass the A2 theoretical exam with this knowledge, but they will need the flight session to validate the diploma.
For the STS diploma, more knowledge is necessary (aeronautical maps, weather reports, dynamics, maintenance...).

Outdoor – students

For outdoor sessions it is interesting for the students to have:

- Notebook, (or smart tab with a pen). This tool allows the learner to write your advices and his own observations and personal tips about how to fly or else directly on the field.
- Smartphone to take pictures or to communicate with the drone or to write notes (an app like "Drawnote" and a pencil can be useful to make drawings).

Outdoor – training area

You must have a declared, secured, clear and interesting flight area

- **Declared:** your university or school director must allow you to fly, so as the owner of the plot, it is mandatory. Once your choice is made (see other criteria) write a letter explaining your choice of an area and the security taken into account. You can argue that the drone activity is close to the practise of sports, and usually the sports area is a good place to fly. The area must also be declared in your MANEX. Depending of the local rules, the air traffic authorities could also be questioned to fly in open category, and MUST be notified to fly in specific category STS01.
- **Secured:** remember that no uninvolved person should be overflown by the drones. Respect the distance to these people and to the buildings when marking your flight area. Use signalling cones or barriers or security strip:

Figure 15: marked-out area in a school playground for C1 certified drones. The drone flight area is around the cones with a rod. The students are on the right, in the shadow and looking opposite to the sun.

Figure 16: security strip is the best (virages.com)

Actually (April 2024) it is still possible to teach flight in open category, so, depending on the drone you use:

- Open category A1, UAS class C1 certified (<900g): you can fly "close" (a few meters) to the limits of your marked flight area. BEST CHOICE TO AVOID SEVERE ACCIDENTS, the lightest the drone, the lightest the accident, and a little drone has the same commands as a big drone.
- Open category A2, UAS class C2 certified (<4000g): you must stay at 50m from the limits of your flight area and if you fly in "low speed mode" (3m/s locked on the remote control) at only 5 meters.
- Open category A3, UAS class C3 or C4 certified (<25kg) : you must stay at 150m from the limits of your flight area and to the buildings...

In the future, it will be mandatory to work with learners in specific category in an STS scenario (or a "learning" scenario to define):

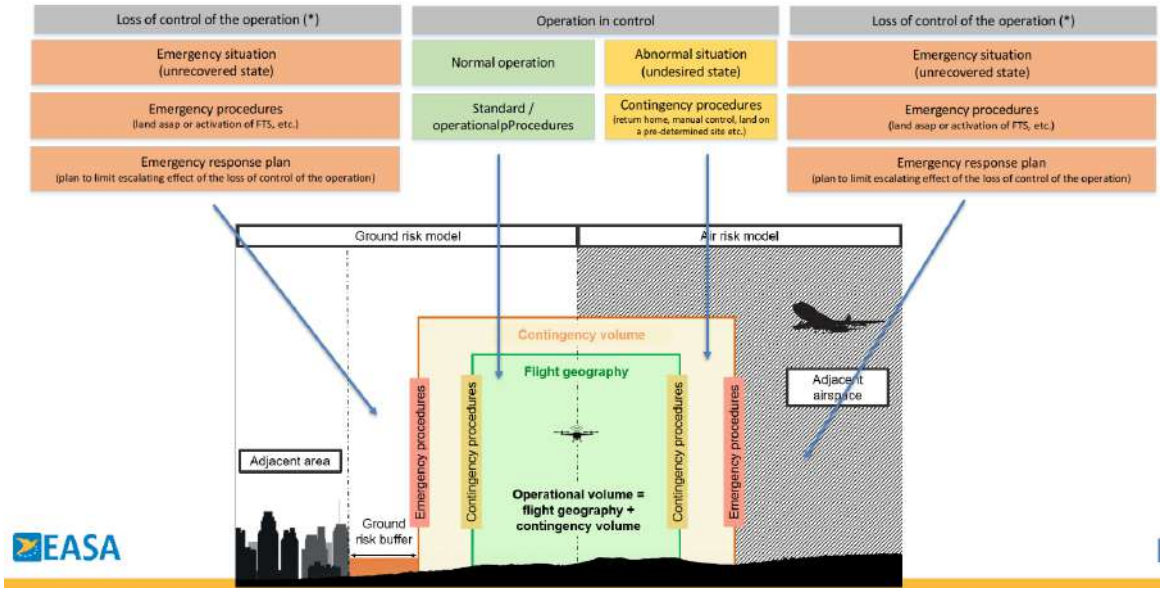

Figure 17: STS01 volumes (EASA)

- Specific category STS01, UAS class C5 certified (<25kg, 5m/s slow speed mode, FTS flight termination system i.e. engine cut-off and parachute): you fly in STS01 scenario and define a "contingency volume" and a "ground risk buffer"

Your students must stay in the operational volume, there they can fly as they wish (or rather as THE TRAINER wishes!) but as soon as they enter the Contingency Volume, the trainer must take control or tell the learner to come back, and if they enter the Ground Risk Buffer you should activate the FTS (flight termination system: engine stop and parachute).
Even if this configuration is drawn for the STS01 scenario, you can use it for the open category.

Require your students to wear a security jacket.

Figure 18 Drone pilot in a secured area with security jacket (Instadrone & Lycée Dhuoda)

Mark the take-off area with a specific take-off plate, a drone landing pad, so as nobody walks by or places some obstacle nearby. It is also useful when the grass is high.

Figure 19: drone landing pad (geomesures.fr)

Clear: no trees, no obstacles in the field, they could hide the drones or create collision risks. Avoid the proximity of buildings, particularly if you fly in A3 open category (150m from constructions), high buildings create GNSS masks that can lower the positioning precision. Beware of electrical lines, they must be out of the flying zone, with a security distance.

Interesting: this is the most difficult to find for a second time flight, because after the pilots have discovered the flight on a flat, "not interesting", clear place, they must practise real-world exercises. It means that you should find a place with relief, with a little construction, or a façade to practise photogrammetry, LIDAR, thermography or expertise. This place must be secured also, uninvolved people must be prevented from passing, the owner must give his consent, it cannot be a public place. Place all the security like for the beginner's place, it is mandatory wherever you work.

Drone choice

Actually (april 2024), the European regulations enable the use of any drone for learning, but should change to C5 UAS if the specific category becomes mandatory. Thus, we recommend to have the lightest possible drone for the beginning of the learning, class C1. It is cheap (500 to 1000€), lightweight (250 to 500g) and flies "like a big one". In case of loss of control, the danger is low and your flight area won't need a large security buffer.

Normally, the picture quality of these drones is far enough sufficient for a photogrammetric process learning. The final 3D model will not be as accurate as with a better lens, but it is not for professional use, and all the functionalities such as geolocation, scaling or classifying are possible.

To learn to take photographs for expertise it is also correct, be aware that a bigger drone will be more stable and easier to manage thanks to its horizontal proximity sensors.

Of course it will be impossible to practise LIDAR for the moment, but we found that thermal cameras exist for little drones like the DJI mini 3 pro.

If it is necessary to go further, or for LIDAR, or to get ready to manage bigger drone then, in a second time you can fly on a larger drone, target class C5 (or C6 for FPV). With a C5 you have the cut-off capacity and the parachute for safety which is very comfortable for learning and to prevent equipment breakage. You'll have to define your STS01 flight zone, and declare it to the authorities.

Preparation – Administrative work to be carried out by the training organisation

First have a frank discussion with the head of the training institute, explain clearly the risks and the measures to contain them. Prepare a file with your wish for a flight area, a classroom, the type of drone you need and the level of knowledge you aim for your students. Pass your exams (see below) then only after this you can decide definitely about the training course and the equipment you want to apply. By your drones and all the necessary tools (see above), and register them, get your ID and tag it on the drone. Take contact with a specialist to write a MANEX (the best is to prepare it yourself and only finalize it with the specialist). Prepare a log book, a maintenance logbook, a flight mission form (example in the D4V modules). Have your manager draw up an authorisation to use the flying area for pilot training.

Outdoor – Flight permits required for instructors

Get trained first to the A1/A2/A3 pilot level If you decide to go to the specific category STS01 scenario, then pass the STS-pilot exam (CATS STS in France for example). As said above, for the moment this configuration is not mandatory but should become the new rule in a close future, so, get ready!

Figure 20: Drone Flight Example (AI generated - Adobe Firefly)

4. Teaching methods

4.1 Traditional vs. progressive teaching methods

The choice of **teaching method** can have a significant impact on learning success. Both traditional and progressive teaching methods that can be used in training for the use of unmanned aircraft systems (UAS) or drones are explained below.
The **traditional form of teaching** is usually **frontal teaching**:
The teacher lectures and the participants act as listeners. Communication is predominantly one-dimensional, but questions from the listeners (pupils) are permitted and (often) encouraged. As a rule, teaching is **teacher-centered** and has **objectivist** features, which can be useful in mathematics, for example, or in many scientific fields (results are generally recognized, e.g. the formal and legal rules for flying a drone). **Constructivist** learning methods focus more on free work by learners, multidimensional communication and discussion of the (usually) open results.

What traditional teaching has in common is that the subject matter is usually conveyed thematically and linguistically, and learning takes place together in a teaching group (class, group); communication and interaction processes are controlled and coordinated by the teacher.

From a didactic point of view, **traditional teaching** is well suited to explaining contexts and problems (from the teacher's perspective), developing new areas of knowledge and consolidating and deepening[1]. Furthermore, it is usually easy for the teacher to check the level of knowledge and training of the learners and to enforce calm, order and discipline. However, there is a risk of tempting learners into passivity.

With **progressive learning methods**, the role of the teacher changes: they must create a suitable learning environment and encourage learners to learn independently. To promote **motivation** (if the learners are not already intrinsically motivated), the topics must be presented authentically and have a connection to reality. Group lessons (groups with the same or different topics) are one way of realising this. The content should be largely developed and internalised independently (independent problem solving, personal responsibility for working together). Communication is two-dimensional: teacher-learner and learner-learner. The teacher takes on the role of a moderator.

However, communication must not be extended to such an extent that the required or expected result takes a back seat. The following aspects must be taken into account:

- Design and customisation of the learning environment
- Attention observation and, if necessary, further motivation
- Controlling emotions and reacting to emotional outbursts
- Dealing with failure

[1] Relevant for teaching the basics of modules 1 (drone regulation), 2 (flight planning), 6 (geolocation), 7 (photogrammetry) and 8 (thermography).

Teachers also face the difficulty of assessing a learner's individual performance. The results should be summarised and reflected upon at the end of the learning process (feedback).
Learners are often overwhelmed by progressive learning methods; these must first be (carefully) learnt. An important and essential prerequisite for open teaching methods is consolidated basic knowledge (instruction) on the respective topic (e.g. the rules of aerodynamics). Only then can the knowledge be applied and further developed (construction). Ideally, instruction and construction complement each other and the learner has developed an individual learning strategy and methodical behaviour.

E-learning (learning with digital media) is a special form of teaching and learning. This currently involves providing educational support to individuals or learning groups using web-based media. A distinction is made here between different types:

- Self-directed learning with ready-made learning content
- Online supervised learning with asynchronous and synchronous means of communication
- Combination of both, possibly as so-called blended learning, also with attendance phases.

All of the teaching and learning methods mentioned above are also possible in principle with e-learning, but the time and organisational effort required for preparation and follow-up as well as for conveying the learning content can be much greater than with pure face-to-face teaching. Success assessments can also be time-consuming.
When teaching knowledge and skills related to the use of drones, a mixture of traditional learning (teaching the basics) and open learning (strategies for the practical implementation of drone flying, definition of goals and results, documentation of experience, guidelines, etc.) can be advantageous in many cases.

Here are some examples of possible lesson plans:

Module 1 - Drone regulation:
It will start with a lecture on current regulations and laws (traditional). Case studies are then discussed in small groups (progressive).

Module 2 - Flight planning and reporting:
Firstly, it is demonstrated how flight planning is carried out (traditional).
Then the learners are asked to create and present their own flight plans (progressive).

Module 3 - Drone dynamics and maintenance:
Firstly, a demonstration of maintenance procedures is carried out (traditional).
The students then work in teams on real drones (progressive).

Module 4 - Flight simulator:
Learners use the simulator individually to practise specific skills (traditional).
Then a group activity is started in which the learners have to work together to fulfil a mission in the simulator (progressive).

Module 5 - Flight practice:
It starts with a demonstration of a drone flight (traditional).
Next, the students carry out their own flights under supervision (progressive).

4.2 Adaptation to different learning styles

Learning is a process that is influenced by various factors. The individual learning style is a crucial aspect that significantly influences the way in which we capture and store information. These individual preferences determine how we best absorb and process new knowledge.
Learning takes place in various stages (basic knowledge transfer - supplementary knowledge - teamwork - practical application) and various paths lead to the **learning objective**.

Learning takes place through ...

- Observe
- Listen
- Read
- Reflect
- Try it out
- Practise
- Overcome
- Failure
- Do it yourself

As a rule, two or more **methods** are combined. The learning outcomes are statistically evaluated with relative certainty:

- 20 % through listening alone
- 30 % by watching alone
- 50 % by listening and watching
- 70 % by listening, watching and additional explanations (e.g. after questions and queries)
- 90 % by listening, watching, explaining and doing it yourself (apply)

It is difficult to teach a heterogeneous group with different channels of perception. A distinction is made (according to Vester):

- Visual learning types (learning with sketches, graphics, mind maps, colour coding, videos)
- Auditory learning types (learning through listening, audio books, podcasts)
- Communicative learning types (learning through exchange with others, discussions and explanations)
- Motor learning types (learning through haptic experience, models, games)

Hardly any of these **learning types** occur in pure culture; most people are mixed types. The more sensory channels are addressed, the greater the learning success will be.

The further development of this model describes the following four learning types:

1. **Why-learner (35% of all people):** questions relevance, needs plausible explanations and learns best through storytelling
2. **What-learner (20 % of all people):** scrutinises procedures, processes, backgrounds, needs statistics or studies to prove or disprove statements
3. **How-learner (20 % of all people):** tries things out and tries to put them into practice; needs a high level of practical relevance, little interest in the theoretical background

4. **What-if-learner (25% of all people):** first absorbs information, reflects and then tries it out; often emotional, needs a concrete perspective on how to apply what they have learnt

Optimal **framework conditions** are a positive learning environment, respect for the diversity of learning styles and the promotion of the individual strengths of each pupil.
The following aspects form an important basis for this:

Individuality: Every learner is unique. It is crucial to recognise and acknowledge the diversity of learning styles. A one-size-fits-all approach does not fit all.
Flexibility: Teachers and trainers should be flexible and use different teaching methods. A mix of visual, auditory, kinaesthetic and written approaches makes it possible to meet the needs of all students.
Awareness: Educators should be aware that learning styles can change over time. A student who learns visually may later learn better through hands-on experiences.
Inclusion: Learning styles should not be seen as an obstacle. Instead, they should be seen as an opportunity to make lessons more inclusive. Individual adaptations can help to ensure that all pupils are successful.
Reflection: Teachers should regularly reflect and adapt their teaching methods. Student observation and feedback are valuable sources for improving teaching.

4.3 Technology in the training room

The technology in the training room plays a decisive role in the training of professionals and should primarily cater for all the types of learners described above.
In addition to a high-resolution projector or a large wall monitor, a whiteboard should also be available for additional notes and sketches. The latter should be large enough to enable more complex sketches to be made and even learners in the back rows of seats should be able to grasp the content.
The teacher's PC must be suitably powerful and the internet connection must also be secure and stable. In emergencies (power failure, power cut), a conventional writing facility should always be available (e.g. blackboard or whiteboard).

From a pedagogical point of view, there are various aspects that should be taken into account:

Models as well as experimental, measuring and testing stations:
In the style of a **station circle**[2], these can help learners to not only learn individual topics, but also to better understand the interrelationships through active participation.

Simulation software and hardware:
In the training room, prospective drone pilots can recreate realistic flight conditions using simulation software and hardware. This technology enables trainees to practise various flight scenarios without having to use real drones. The simulation helps to learn flight manoeuvres, deal with dangerous situations and improve flight performance.

Interactive learning platforms:
Digital learning platforms offer students the opportunity to familiarise themselves with theoretical knowledge about drones. These platforms can include videos, interactive modules, quizzes and case studies. Teachers can track students' progress and provide individualised support.

Live streaming and remote access:
Modern classrooms can be equipped with cameras and live streaming technology. This allows students to follow flight demonstrations in real time, even if they are not physically present. Teachers can give students feedback and answer questions remotely.

Data analysis and processing:
Processing flight data is an important part of drone training. In the classroom, students can learn how to analyse flight data, identify errors and make improvements. Data processing and analysis technology should therefore be included in the curriculum.

Ethics and safety:
Educational approaches should also cover ethical and safety aspects. Students need to understand how to use drones responsibly and comply with data protection guidelines. Technology can help to simulate realistic scenarios in which ethical decisions need to be made.

[2] Relevant for modules 4 (flight simulator), 5 (flight practice), 9 (lidar) and 10 (pictures for expertise)

4.4 Technology for e-learning sessions

For any planned e-learning sessions, it makes sense to provide PCs, notebooks or tablets for the participants. In this way, the accessing and (independent) development of learning content can be explained in a targeted manner. The process of online teaching can also be tested and practiced (establish and demand clear rules of communication and behavior!).

E-learning consists of several elements, for example media-supported self-learning, web-based collaboration between learners or joint teaching in a virtual seminar room.

Pre-prepared learning media (e.g. videos) enable self-directed, time-independent learning. However, a great deal of time must be expected for the creation and, above all, the maintenance of the content (rule: 20-50 hours of creation per 1 hour of finished content, even more for very demanding content).
There are currently many options available for **collaborative learning**, such as WhatsApp or Telegram groups or other professional services. The formation of learning networks can be encouraged by the teacher, but learners usually already use this option independently.

The **virtual seminar room** is usually subject to a fee, especially if many communication channels are to be used. In addition to **Teams video conferencing** from Microsoft or **Connect** from Adobe, **WebEx** and **Go2Meeting** are also worth mentioning here. The performance of the respective system can usually be tested for a limited time in free trial versions. This can take a long time, but should definitely be invested in order to achieve good results.

In addition to pure conference systems, the use of **additional programmes** can be useful depending on the requirements. Example: virtual whiteboards that enable handwritten texts and sketches (with a pen tablet). Experience has shown that this is more popular with almost all learners than entering text using a keyboard. The texts and sketches can be saved and can be sent to the learners if necessary (but be careful: this must not stop the learners from writing or sketching themselves!)

Comprehensive **collaboration tools** such as Microsoft Teams or Google Workspace offer a wide range of options for intensive collaboration or dynamic exchange. An online search will certainly provide many suitable results and an individual decision can be made.

Another tool is Q&A software, such as **Mentimeter**. It enables the creation of intermediate questions and queries as well as complex quizzes with concrete evaluation. This tool (used moderately) also enjoys a high level of acceptance in practice, as learners are immediately active and receive direct feedback. They also loosen up the online lessons. The survey results can then be exported and made available to the learners (option for mapping and targeted repetition).

It goes without saying that the teacher should have extensive experience with e-learning sessions and not only be proficient in the technology, but also be able to support the learner if necessary. Furthermore, they should have a "plan B" ready so that the learning processes can continue even in the event of network or system failures.

Sources:

Revised training materials from the "TeleCoach" course (TCI, 2008, Verlag ets didakta media); dlr.de; lubb.berlin-brandenburg.de

5. Collaboration and Communication

Collaboration and communication in teaching can take various forms. This module identifies some of the collaboration and communication methods that can be used to promote an active learning environment for both teachers and students for the Drones4VET program. The following section includes some of the types of (**a**) collaboration, (**b**) communication (**c**) delivery methods that are available to teachers/lecturer to deliver this Eramus+ program which includes both theoretical and practical module content.

5.1 Collaboration

With respect to Synchronous and asynchronous delivery methods, there are a number of collaboration methods available to both teachers and students as highlighted in the next table.

Collaboration Methods		
Synchronous Approach		**Asynchronous Approach**
Face-to-Face Interaction (F2F):	**Online Collaboration (LIVE):**	**Flipped Classroom Approach: (Not LIVE)**
Lectures: Traditional classroom lectures where the teacher imparts knowledge to students. **In class Discussions:** Interactive sessions where students can actively participate, share ideas, and ask questions for both individual and group-based assignments. **Interactive inclass Whiteboards** Interactive whiteboards like SMART or Promethean can be used for collaborative writing, drawing, and problem-solving.	**Learning Management Systems (LMS):** Online material delivery using LMS system such as Canvas, Moodle, etc. **Online Whiteboards / Virtual Work Space** Online platforms such as MIRO, where students can actively collaborate with teachers or in a group-based environment using an online virtual whiteboards. See Figure 1 for details. **Discussion Forums:** Virtual platforms where students can discuss topics, ask questions, and share resources. **Chat Rooms:** Real-time text-based communication for quick exchanges and discussions. **Video Conferencing**: Platforms like Zoom or Microsoft Teams enable live video interactions, allowing for a more immersive online experience.	**Pre-recorded Lectures:** Instructors provide recorded lectures for students to watch before class, allowing in-class time for discussions and activities. Typically, use of LMS or other online repository for material access. Students may adopt some of the online delivery collaboration strategies for an asynchronous approach also.

Table 4: Collaboration Methods for Synchronous and asynchronous delivery methods

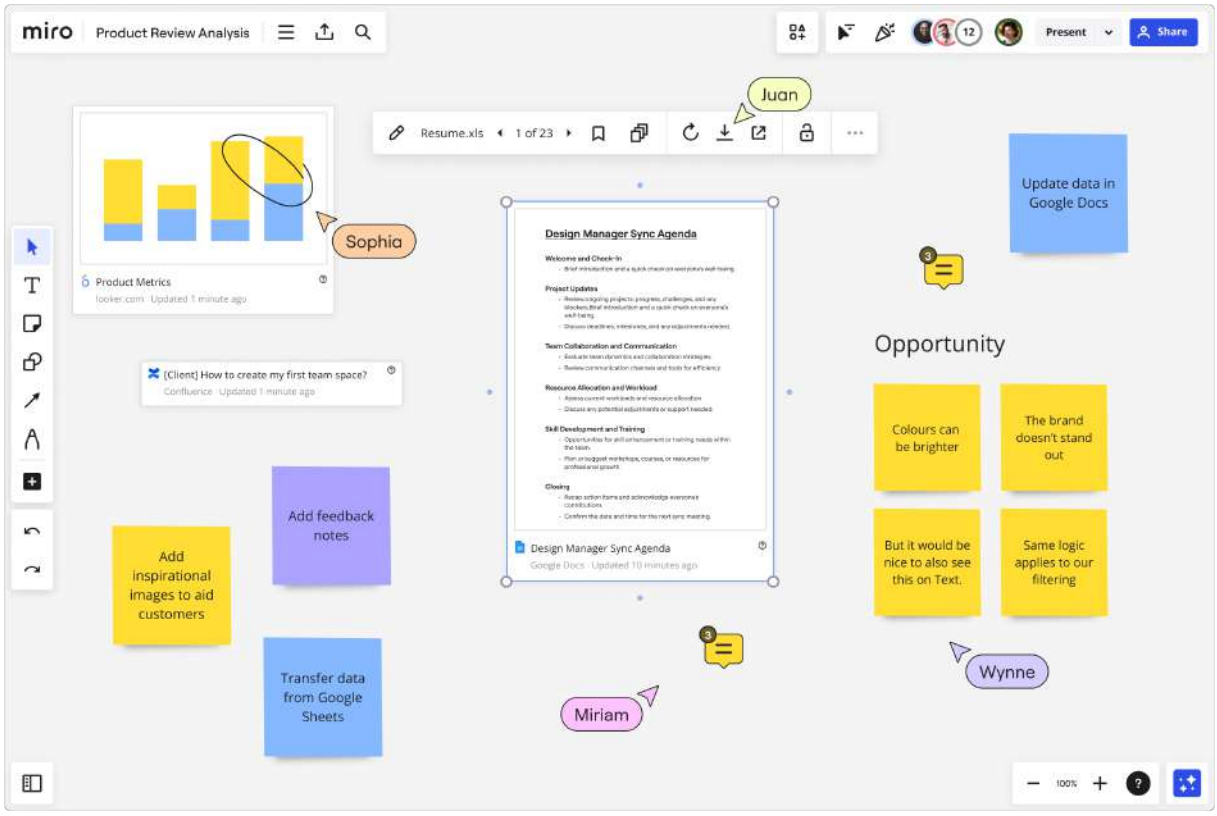

Figure 21 Example of the Online Collaboration Tool Miro [Miro | The Visual Workspace for Innovation](#) – For Individual or group-based activities/assignments.

5.2 Communication:

To allow for efficient and effective collaboration between students or students and lecturers/teachers, there is a need to establish adequate communication methods. This is to allow efficient information exchange between the forementioned parties. The 3 main types of communication in a classroom-based environment include:

- Verbal Communication
- Non-Verbal Communication
- Written Communication

With reference to synchronous (F2F & live) and asynchronous (not live) program delivery, the following table highlights typical communication methods for each type of delivery:

Table 5: Communication methods/tools per type of course delivery.

Communication Methods	Details	Types of Delivery		
		F2F	Online/Live	Pre-recorded
Email	Traditional email communication for one-on-one or group discussions.	✓	✓	✓
Discussion Boards	Platforms where students can post comments or questions at their convenience.	✓	✓	
Learning Management Systems (LMS)	An online platform that allows for course/module delivery. It contains a number of functionalities such as: online meeting, file/notes sharing, announcements, assignments submissions and others (examples include Canvas, Moodle etc)	✓	✓	✓
Announcements	Instructors can use LMS platforms to make announcements and share important information.	✓	✓	✓
File Sharing	Uploading and sharing course materials, documents, and resources.	✓	✓	✓
Interactive Whiteboards	Platforms like SMART or Promethean can be used for collaborative writing, drawing, and problem-solving.	✓	✓	
Online Polls and Surveys	Tools like Poll Everywhere or Mentimeter can be used to gauge student understanding and opinions.	✓	✓	✓
Feedback Mechanisms	Surveys and Feedback Forms: Gathering feedback from students to improve the teaching and learning experience.	✓	✓	✓

5.3 Module Delivery

Blended learning is a modern approach to teaching and learning where teachers can leverage the benefits of the different teaching styles to best deliver the content that they are teaching. The following table suggests some of the recommended delivery strategies for each module of the Drones4VET program.

Table 6: Suggested delivery method for Drones4VET modules

		Delivery Type			
Module No	**Module Name**	**F2F**	**online**	**Recorded**	**Practical Delivery**
M1	**Drone Regulations**	✓	✓	✓	**X**
M2	**Flight Planning & Reporting**	✓	✓	✓	**X**
M3	**Drone Dynamics & Maintenance**	✓	✓	✓	**X**
M4	**Flight Simulator**	✓	✓	✓	✓
M5	**Flight Practice**	**X**	**X**	**X**	✓
M6	**Geolocation**	✓	✓	✓	✓
M7	**Photogrammetry**	✓	✓	✓	✓
M8	**Thermography**	✓	✓	✓	✓
M9	**LIDAR**	✓	✓	✓	✓
M10	**Pictures for Expertise**	✓	✓	✓	✓

6. Hard- and Software technology for Drones4VET

Table 7: Hard- and Software

No	Module Name	HARDWARE	SOFTWARE/APP	OTHERS INFORMATION OF INTEREST
1	DRONE REGULATION 	**PC:** Intel® Core™ i3 Intel® HD 8 GB DDR5 512 GB SSD	**OPERATING SYSTEM:** Windows 11 Microsoft Office 2021 Adobe Acrobat	**WEBS:** https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-unmanned-aircraft-systems-regulations-eu https://www.easa.europa.eu/es/light/topics/guide-drone-operators
2	FLIGHT PLANNING AND REPORTING 	Computer: same as mod.1 Internet connection Drone remote control or simulator for settings.	Basic software: same as mod.1 Software to display the drone's remote control on the screen. Software to view the students' screens from the instructor's workstation to see if they are making the right settings on their remote control.	**WEBS:** Operations UAS/Drones – Open Category (Subcategories A1, A2 and A3) https://www.easa.europa.eu/en/domains/civil-drones-rpas/open-category-civil-drones **APPS:** https://www.dji.com/es/downloads/djiapp/dji-go-4 https://mapper.ugcs.com/ https://www.pix4d.com/es/producto/pix4dcapture/

3	DRONE DYNAMICS AND MAINTENANCE 	Computer: same as mod.1 Internet connection At least one quadcopter drone to demonstrate attitudes and external components If possible, a "traditional" model airplane If possible, a disassembled quadcopter drone to show internal components	Basic software: idem mod.1 If selected locally: drone maintenance and flight recording software Software to display the drone's radio control on screen. Software that allows you to view the students' screens from the instructor's workstation to see if they are making the right settings on their remote control and writing the right reports in their logbook.	
4	FLIGHT SIMULATOR 	ZEPHYR: - A computer that meets the minimum requirements to run Zephyr (see below) - A supported controller or transmitter with our USB adapter (if applicable) - An internet connection https://zephyr-sim.com/features/1 REALFLIGHT: - Operating System: Windows Vista®, 7, 8.x, or 10 - Processor: Intel Pentium 1.0 GHz or equivalent - Graphics: 3D accelerated video card with 32 MB of dedicated video memory and full DirectX 9 support (Pixel Shader 2.0) - Hard Drive Space: 3 GB - System Memory: 512 MB RAM	ZEPHYR: https://zephyr-sim.com/ REALFLIGHT: https://www.realflight.com/rfl-bs-updates.html	ZEPHYR DEMO VERSION: https://zephyr-sim.com/individuals REALFLIGHT: https://www.realflight.com/

		- Installation: Internal or External DVD Drive (A downloadable alternative to the installation disk is not available) Optimal System - Processor: Dual Core 2.4 GHz CPU - Graphics: 3D accelerated video card with 512 MB of dedicated video memory (Pixel Shader 3.0) - System Memory: 2 GB RAM InterLink Elite Controller: - USB Port - Compatible FM or FM-selectable transmitter (if using the interface mode) - The connectors on the InterLink Elite Controller interface cord and included adapter are compatible with the trainer ports on most Futaba and all JR, Spektrum, and Tower Hobbies systems https://www.spektrumrc.com/support/ PHOENIX R/C PRO - 256MB system memory (RAM) - 1.5 GB free, uncompressed hard-disk space - ATI Radeon 9800/NVidia Geforce Ti4200 with at least 128MB memory or better - Microsoft DirectX 9.0c or higher	PHOENIX R/C PRO https://phoenix-r-c-launcher.software.informer.com/5.0/ DJI FLIGHT SIMULATOR	PHOENIX R/C PRO https://www.rc-thoughts.com/phoenix-sim/ DJI FLIGHT SIMULATOR USER MANUAL: https://dl.djicdn.com/downloads/simulator/2

		DJI FLIGHT SIMULATOR - Minimum System requirements: Processor: G4560; Graphics: GTX 1050 Ti; Memory: 16GB RAM; HDD: 80GB Free - Recommended System requirements: Processor: i5-6400; Graphics: GTX 1060 or GTX 1070; Memory: 16GB RAM; HDD: SSD+80GB Free - Optimal System requirements: Processor: i7-7700; Graphics: GTX 1080 Ti; Memory: 32GB RAM; HDD: SSD+80GB Free DJI remote controllers Use a USB cable to connect the remote controller's Micro USB port to the PC's USB port	It only supports the Win10 64-bit operating system. www.dji.com/es/downloads/products/simulator?site=brandsite&from=insite_search	0200612/DJI_Flight_Simulator_User_Manual_v1.4_EN.pdf

5	FLIGHT PRACTICE 	Computer: same as mod.1 Internet connection Secure, declared, authorized and unobstructed flying site Between 1 to 4 drones, depending on available space. Class C1 for beginners (note that regulations may evolve towards class C5 for teaching purposes). Very light <500g: DJI mini AUTEL EVO NANO PARROT ANAFI Light <900g: FIMI X8 AUTEL EVO LITE DJI MAVIC Not exhaustive list Building site cones, signs and warning tape. Take-off areas	Word processing for mission sheet, if required Weather applications (UAV forecast…) or METAR-TAF website (allmetsat.com…)	**APP:** https://www.dji.com/es/downloads/djiapp/dji-go-4 https://www.dji.com/es/downloads/djiapp/dji-fly https://www.dji.com/es/downloads/djiapp/dji-pilot
6	GEOLOCATION 	Computer: same as mod.1 Internet connection GNSS receiver (GPS) + RTK module with active subscription. Targets (checkerboards) on the ground	National geodetic website	

7	PHOTOGRAMMETRY 	PC for 3D computations 16Go memory 1To SSD with 100Go free Dedicated Graphic card 8Go (possible without, slower) Drone + camera (16MPix, programmable shoots, better with a mechanical shutter)	Programmed flight application for the drone DJI PILOT UGCS PIX4D CAPTURE PIX4D MAPPER Photogrammetric processing software AGISOFT METASHAPE MESHROOM	APP: https://www.dji.com/es/downloads/djiapp/dji-pilot https://mapper.ugcs.com/ https://www.pix4d.com/es/producto/pix4dcapture/ https://support.pix4d.com/hc/en-us/articles/115002439403-Software-download-and-installation-PIX4Dmapper https://www.agisoft.com/ https://github.com/alicevision/Meshroom
8	THERMOGRAPHY 	Powerful PC 16GB memory 1TB SSD with 100GB free space 8GB dedicated graphics card (possible without, slower) Drone + thermal camera	Thermal analysis software depending on your camera DJI Thermal Analysis Tool 3 Flir Tools	WEB: https://www.dji.com/es/downloads/softwares/dji-dtat3 https://www.flir.es/products/flir-tools-app/?vertical=condition+monitoring&segment=solutions

9	LIDAR 	PC for 3D calculations 16GB memory 1TB SSD with 100GB free space 8GB dedicated graphics card (possible without, slower) Drone capable of carrying a LiDAR sensor Example DJI M350 RTK (C3) + DJI ZENMUSE L2 LIDAR	Software for processing LiDAR data from your sensor Programmed flight application for the drone DJI PILOT UGCS PIX4D CAPTURE PIX4D MAPPER	APP: https://www.dji.com/es/downloads/djiapp/dji-pil https://mapper.ugcs.com/ https://www.pix4d.com/es/producto/pix4dcapture/ https://support.pix4d.com/hc/en-us/articles/115002439403-Software-download-and-installation-PIX4Dmapper https://www.agisoft.com/ WEB: Matrice_350_RTK_User_Manual_v1.0_ENl.pdf (djicdn.com) Zenmuse_L2_User_Manual_v1.0_ES.pdf (djicdn.com)
10	PICTURES FOR EXPERTISE 	Powerful PC 16GB memory 1TB SSD with 100GB free space 8GB dedicated graphics card (possible without, slower) Drone + very good camera, possibly with quality zoom lens	Drone remote app Software for pictures: Xnview (basic and free) Photoshop	

7. Assessment and Feedback in Effective Teaching

Assessment and feedback are integral components of any successful teaching course, playing a crucial role in gauging the students understanding of the material and fostering continuous improvement. In this module, we will explore some of the primary and optional assessment tools as highlighted in Figure 1 that may be adopted for assessing the teaching and learning on the Drone4VET program. The importance of constructive feedback for enhanced learning outcomes is also discussed.

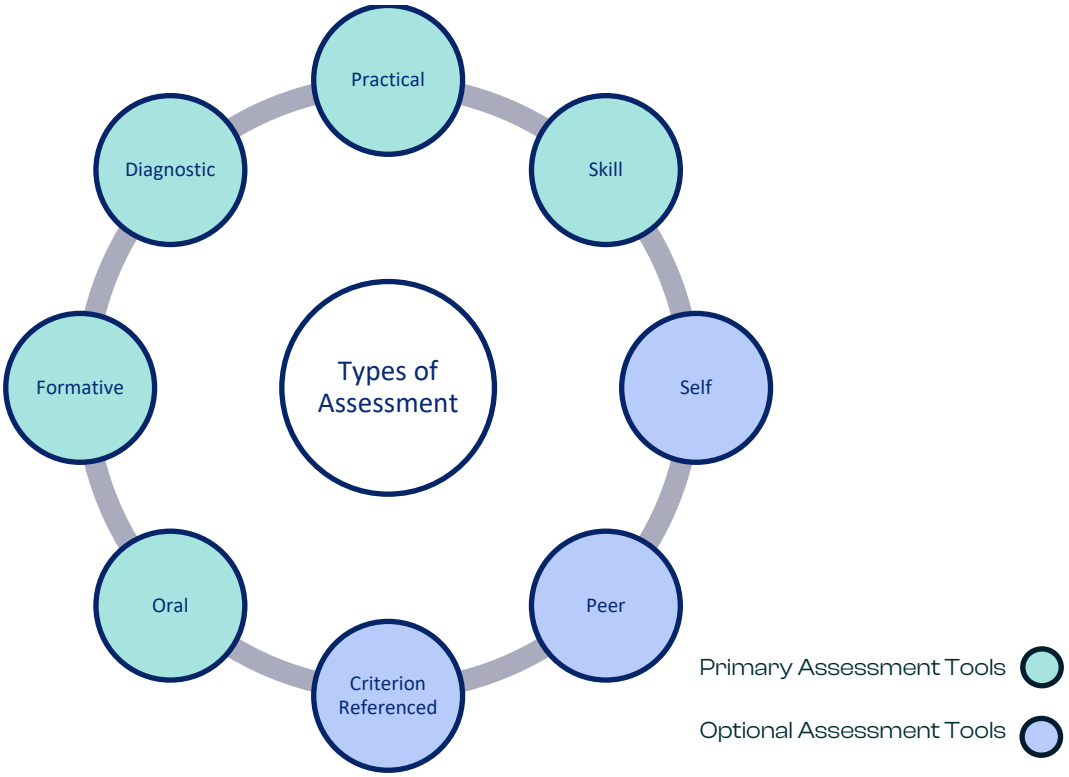

Figure 22 Types of Assessment Strategies

7.1 Different Types of Assessments to assess learning:

- A practical assessment is based on practical activities that are intended to assess and observe the practical skills and behavior of students.
- Diagnostic assessment is a type of assessment to check a student`s current knowledge base. Typically, it involves a series of questions given at the start of a class or training session to identify a learner's strengths and weaknesses prior to learning. Examples include Journals, Quiz/Test, Conference/Interview, Posters, Performance Tasks, Mind Maps, Gap-Closing, Student Surveys
- Formative Assessments: These ongoing assessments allow instructors to monitor student progress and understanding during the course. Examples include quizzes, polls, and short assignments.
- Summative Assessments: These assessments are conducted at the end of a learning period to evaluate overall comprehension. Examples include final exams, projects, or comprehensive tests.
- Skill assessment: in order to measure students' ability to perform certain tasks, skill assessment is the preferred type. It could be a part of a practical assessment.
- Oral assessment: evaluation of knowledge gained by a student in an oral form.
- Criterion-referenced assessment: assessment of a student's knowledge based on pre-determined criteria and standards.
- Norm-referenced assessment or Peer Assessments: Students evaluate the work of their peers, promoting collaboration and providing valuable insights from different perspectives.
- Self-Assessment: Encouraging students to reflect on their own learning fosters a sense of responsibility and helps them identify areas for improvement.

The following table maps suggested assessment types for use for the Drones4VET modules:

Table 8: Suggested module assessment

Drones4VET Module & Suggested Assessments										
Assessment Type	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
Practical	X	✓	X	✓	✓	X	X	X	X	X
Diagnostic	✓	✓	✓	X	X	✓	✓	✓	✓	✓
Formative	✓	✓	✓	X	X	✓	✓	✓	✓	✓
Summative	✓	✓	✓	X	X	✓	✓	✓	✓	✓
Skill	X	X	X	✓	✓	X	✓	✓	✓	✓
Oral	✓	✓	✓	X	X	✓	✓	✓	✓	✓
Criterion-referenced	✓	✓	✓	X	X	✓	✓	✓	✓	✓
Norm-referenced	✓	✓	✓	X	X	✓	✓	✓	✓	✓
Self-Assessment	✓	✓	✓	X	X	✓	✓	✓	✓	✓

***M1 – Drone Regulations, M2 – Flight planning and reporting, M3 – Drone Dynamics and maintenance, M4 – Flight simulator, M5 – Flight Practice, M6 – Geolocation, M7 – Photogrammetry, M8 – Thermography, M9 – LIDAR, M10 – Pictures for expertise**

LEGEND:

✓	**Suggested**
X	**not advisable**
✓	**Optional**

With respect to F2F and online delivery, the following table outlines how formative assessment (most commonly adopted assessment technique) may be carried employed for both individual and group based assignments,

Table 9:Types of assignment and tools for F2F and online collaboration

Types of assignment and tools for F2F and Online collaboration		
Type of Assessment	**Approach**	**Tools for Collaboration and communication**
Formative & Summative Assessments / Individual Assignment:	This type of assessment is carried out by an individual student therefore collaboration is kept to minimum unless students decide to carry it out in a parallel manner, where group of students works together but submissions are individual.	If students working in parallel manner approach can be as a group project below.
Formative Assessments / Group Projects	Collaborative Assignments: Tasks that require students to work together, promoting teamwork and shared responsibility. Peer Review: Students review and provide feedback on each other's work, fostering a collaborative learning environment.	Social Media Groups: Creating dedicated groups on platforms like Facebook or LinkedIn for class discussions and resource sharing. Blogs: Students can create and share blogs to express their thoughts, experiences, and insights related to the course.

7.2 Feedback and Improvement

Effective feedback is a cornerstone of the learning process. It not only informs students about their performance but also guides them toward improvement. In this section, we will focus on the following aspects:

- Timely Feedback: Providing prompt feedback allows students to address misconceptions and make necessary corrections in a timely manner.
- Constructive Criticism: Feedback should be constructive, highlighting both strengths and areas for improvement. Specific and actionable feedback guides students toward enhancing their skills.
- Feedback Mechanisms: Explore various tools and methods for delivering feedback, such as written comments, verbal feedback, or digital platforms.
- Feedback for Motivation: Positive reinforcement and acknowledgment of achievements contribute to student motivation and engagement.

Directories

Figures

Tables

Appendix

Own Templates and Tools