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Deliverable of Activity

A2.1 Educational material and state-of-the-art methodology for deploying Drone Technology

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Acronyms

Acronym	Explanation
UAVs	Unmanned Aerial Vehicles
UAS	or Unmanned Aircraft Systems

Executive Summary

Deliverable A2.1 serves as a foundational component of Work Package 2 (WP2), focusing on bridging the theoretical and practical gaps between education and the drone industry. The deliverable identifies critical discrepancies between academic preparation and industry demands through comprehensive analyses of educational materials, industry trends, and stakeholder input. By highlighting the benefits, challenges, and evolving applications of drones, this work emphasizes the need for interdisciplinary integration, hands-on training, and regulatory awareness in drone-related education.

The analysis is structured across four key tasks. Task T2.1.1 explores theoretical and practical gaps through an extensive review of educational resources and industry practices, identifying areas requiring improvement, such as real-world applications, technical skills, and regulatory compliance. Task T2.1.2 delves into the lack of practical and lab materials, addressing barriers like cost, access to equipment, and rapidly evolving technologies. Task T2.1.3 synthesizes insights from consortium partners, ensuring diverse expertise informs the findings. Finally, Task T2.1.4 outlines a Drone Deployment Framework, focusing on sustainability, regulatory compliance, and interdisciplinary collaboration to guide the integration of drones across various industries.

The findings of this deliverable directly inform subsequent activities, particularly A2.2, which focuses on curriculum development, ensuring alignment with identified gaps and industry trends. Additionally, it provides a basis for other work packages, including WP3, which develops mobile applications to support drone operations, WP4, which establishes an open digital hub for drones, and WP5, which conducts a case study on drone applications in agriculture.

By addressing current educational and industry challenges, Deliverable A2.1 lays the groundwork for advancing drone technology adoption in a sustainable, effective, and innovative manner, fostering collaboration between academia and industry while supporting the overarching goals of the project.

1. Introduction

1.1 Purpose of the Deliverable

The purpose of this deliverable is to establish a comprehensive understanding of the theoretical and practical gaps between education and the drone industry, facilitating the development of innovative educational strategies and industry applications. By analyzing current educational materials, industry trends, and practical challenges, the deliverable aims to create a framework for bridging these gaps through interdisciplinary collaboration and sustainable practices. This work emphasizes the importance of integrating emerging technologies, regulatory knowledge, and hands-on skills into educational curricula to better prepare students for real-world applications in various industries. It seeks to align academic and industry perspectives to foster innovation, enhance employability, and promote the responsible adoption of drone technology across diverse domains, including green business solutions. Through its structured approach, the deliverable contributes to advancing drone education and its alignment with evolving industry demands.

1.2 Relation with other Deliverables

The relevance of Deliverable A2.1 within the broader framework of the project lies in its foundational role within WP2 and its interconnectedness with subsequent deliverables across other work packages. As the initial step in WP2, A2.1 provides the essential insights by identifying theoretical and practical gaps between education and the drone industry, which directly inform the development of A2.2 (Curriculum Development). The findings of A2.1 shape the structure and content of the curriculum, ensuring it aligns with industry needs and emerging trends. Furthermore, the knowledge generated in A2.1 contributes indirectly to WP3 (Mobile Apps Supporting Drone Flights) by highlighting practical challenges and technical requirements for educational and professional applications. It also aligns with WP4 (Drone Open Digital Hub), as the gaps and recommendations identified in A2.1 will guide the creation of digital resources and collaborative platforms. Lastly, WP5 (Drones for the Agriculture Industry: A Case Study) benefits from A2.1 by leveraging the identified knowledge gaps and industry trends, particularly in agriculture, to ensure practical applications and case studies are effectively integrated into the educational and technological solutions. This deliverable thus serves as a critical cornerstone for cohesive and impactful project outcomes.

1.3 Structure of the Document

The deliverable is structured around the key tasks outlined in Activity A2.1 to comprehensively address the objectives of identifying and analyzing the gaps between education and the drone industry. Task T2.1.1 focuses on identifying theoretical and practical gaps through an extensive analysis of educational materials, industry trends, and current practices. Task T2.1.2 examines the lack of practical and lab materials, highlighting the continuous needs of drone technology and its deployment. Task T2.1.3 incorporates information gathering and evaluation based on the expertise and experiences of consortium partners to ensure a well-rounded understanding. Finally, Task T2.1.4 develops a Drone Deployment Framework, addressing interdisciplinary applications and green business solutions.

2. Background information

Drones, also known as Unmanned Aerial Vehicles (UAVs) or Unmanned Aircraft Systems (UAS), have seen a surge in popularity and usage in various fields, including education. Their ability to capture real-time data, provide a bird's-eye view, and engage students in hands-on learning experiences has sparked interest in integrating them into educational settings. Educational institutions and educators have started to incorporate drones into their curriculum to provide a hands-on and interactive learning experience for students.

The aim of this activity (A2.1) is establish open innovation and co-creation mechanism between academia and industry via common educational opportunities to identify and analyze the theoretical and/or practical gaps between education and the drone industry. This requires a comprehensive examination of educational materials and industry trends. Conducting an extensive analysis of educational materials and industry reports can provide insights into how well education is preparing students for the demands of the drone industry and by that point out theoretical and/or practical gaps between education and drone industry.

3. T.2.1.1: Find out the extent of the theoretical/practical gap between education and drone industry, through an extensive education material/corpus analysis

3.1 Introduction

The aim of this task (T2.1.1) is to identify and analyze the theoretical and/or practical gaps between education and the drone industry. This requires a comprehensive examination of educational materials and industry trends. Conducting an extensive analysis of educational materials and industry reports can provide insights into how well education is preparing students for the demands of the drone industry and by that point out theoretical and/or practical gaps between education and drone industry. For this purpose, we reviewed existing literature, specifically scientific literature, but also gray literature and technological blogs/websites, and we elaborate on: overview of current application of drones in education; reported benefits about drones in education; exploring drone industry trends; Identifying theoretical and/or practical gaps between the educational use of drones and drone industry by a point to point comparison of the previous findings. This task, includes 4 sub-tasks.

3.2 T.2.1.1.1 Overview of the application of drones in education

This section provides a comprehensive overview of the application of drones in education for the purpose of understanding the extent of the theoretical/practical gaps between education and the drone industry. The overview covers the purposes for which drones are utilized, the educational topics they are integrated into, and the benefits and challenges associated with their use.

Educational topics where drones are used:

STEM Education

One of the most common applications of drones in education is in the STEM (Science, Technology, Engineering, and Mathematics) fields. Drones provide a practical and engaging way to teach concepts related to physics, mathematics, engineering, and computer science. For example, students can learn about aerodynamics, flight mechanics, programming, and robotics by building and operating drones. There have been several studies and pilot programs that have shown positive outcomes in terms of student engagement and learning. For example, a study by Karp et al. (2020) found that using drones in STEM education helped to increase student motivation and engagement. Specifically:

- **Science:** Drones are used to collect data for environmental studies, ecology, and atmospheric research. They enable students to study hard-to-reach areas and monitor wildlife populations.
- **Technology:** Drones offer a practical platform for learning about robotics, programming, and sensor integration. Students can code flight paths and program autonomous missions.

- **Engineering:** Drones provide a tangible context for lessons on aerodynamics, materials science, and design principles. Students can design, build, and test their drones.

Geography and environmental sciences:

- Drones equipped with cameras and sensors can be used to collect data related to topography, vegetation, wildlife, and other environmental factors. This provides a practical way for students to learn about geography, environmental science, and data collection and analysis. For instance, a study by Anderson and Gaston (2013) discussed the potential of drones for ecological research and education.
- Drones equipped with various sensors and cameras can be immensely beneficial in the study of geography and environmental science. They can be used for mapping landforms, monitoring vegetation changes, studying wildlife, assessing water quality, and monitoring other environmental factors such as air pollution. This provides students with a practical method for learning about various aspects of geography, environmental science, and data collection and analysis.
- Drones are employed to create detailed 3D maps, monitor landforms, and study geological formations. They assist in analyzing topography and changes in landscapes over time.
- Incorporating drones into the geography and environmental science curriculum can provide students with hands-on experience in data collection, analysis, and interpretation. It can also help in developing their skills in using advanced technology for environmental monitoring and research.

Agriculture

- Drones are used to monitor crop health, assess soil quality, and manage irrigation. They aid in precision agriculture by identifying areas requiring attention.

Photography and Videography:

- Drones offer a unique perspective for photography and filmmaking classes. Students can capture aerial imagery, create documentaries, and develop visual storytelling skills.

Archaeology and Anthropology:

- Drones assist in surveying archaeological sites, creating digital reconstructions, and mapping historical landscapes. They help researchers and students visualize past civilizations.

Media and Journalism:

- Drones enable journalism students to cover events from different angles and provide aerial footage for news reports. They enhance storytelling through immersive visuals.

Emergency Management and Disaster Response:

- Drones are used to assess disaster-affected areas, locate survivors, and plan relief efforts. They simulate real-world scenarios for emergency management training.
- Drones can be used to monitor wildlife populations, their movement patterns, and habitats without disturbing them. This can provide valuable data for conservation efforts and studies on animal behavior.

Reported benefits around the educational use of drones

After reviewing the educational topics where drones are used (section 2.1), we synthesized the benefits that the articles reported on. These can be summarized as follows:

- Engagement: Drones capture students' attention and make learning more exciting and interactive.
- Hands-On Learning: Students can directly operate drones, fostering practical skills and problem-solving abilities.
- Real-World Applications: Drones expose students to real-world scenarios and applications in various fields.
- Data Collection: Drones provide access to data that would otherwise be challenging to obtain, enhancing research opportunities.

Reported challenges around the educational use of drones

After reviewing the educational topics where drones are used, we synthesized the challenges that the articles reported on. These can be summarized as follows:

- Cost: Acquiring and maintaining drones can be expensive for educational institutions.
- Regulations: Navigating aviation regulations and obtaining necessary permissions for drone use can be complex.
- Technical Skills: Integrating drones requires training educators and students in piloting, programming, and maintenance.

3.3 T2.1.1.2: Exploring drone industry trends

The drone industry has experienced significant growth and transformation over the past decade. A review of recent trends highlights several key developments. Here we elaborate on the main key trends and developments we identified.

- **Commercial Applications:** Drones are increasingly being used across various industries such as agriculture, construction, real estate, logistics, and filmmaking. They offer cost-effective solutions for tasks like surveillance, mapping, and inspection.
 - **Regulation and Compliance:** Governments worldwide have been working to establish regulations for drone operations. Striking a balance between ensuring safety and fostering innovation has been a challenge. The industry is evolving to meet regulatory requirements, including remote identification and tracking systems. Specifically the EASA provides the Easy Access Rules for Unmanned Aircraft Systems (Regulations (EU) 2019/947 and 2019/945), revised in September 2022 that are listed in appendix A. However, individual member states can add additional rules and regulations which makes it difficult to educate on drone laws on a European level.
 - **Technological Advancements with AI and machine learning:** The integration of artificial intelligence (AI) and machine learning in drone technology is one of the most significant trends. This development will enable drones to perform complex tasks with minimal human intervention, opening up a world of possibilities in various industries. For example, drones equipped with AI-powered navigation systems can autonomously inspect infrastructure, while AI-based data analysis capabilities can help monitor and manage agricultural yields more effectively.
 - **Improved Battery Life and Charging Solutions:** Battery life has always been a limiting factor for drones. However, recent advancements in battery technology and charging solutions are set to change this. In 2023, it is expected that drones with longer flight times, thanks to more efficient batteries and innovative charging systems like wireless charging and solar-powered solutions. These improvements will enable drones to perform tasks more efficiently and expand their range of applications.
 - **Swarm Technology and Collaborative Drones:** Swarm technology is another development in the drone industry. This innovation enables multiple drones to communicate and collaborate in real-time, allowing them to execute tasks more efficiently. Swarm technology has numerous applications, including search and rescue operations, environmental monitoring, and even choreographed entertainment shows. As this technology matures, we can expect to see more collaborative drone solutions in various sectors.
 - **Data Analytics and Imaging:** Drones gather vast amounts of data through high-resolution cameras and sensors. The industry trend is shifting towards utilizing this data for actionable insights, such as crop health analysis, infrastructure monitoring, and 3D mapping.
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- **Delivery Drones:** Major companies, such as Amazon and Google, have already begun testing drone delivery systems, with more businesses expected to follow suit. As regulations continue to evolve and technology advances, we further growth in drone delivery services is anticipated.
- **Drone-as-a-Service (DaaS):** Just like Software-as-a-Service (SaaS), DaaS is gaining traction. Companies provide drone services on-demand, reducing the need for organizations to invest in their drone fleets. This trend is gaining traction as it allows businesses to access cutting-edge drone technology without the upfront investment in equipment and training. In 2023, it is expected to see more DaaS providers emerge, catering to a wide range of industries and applications.
- **Education and Training:** As the industry grows, there's a rising demand for skilled drone pilots and operators. Educational programs, both online and in-person, have emerged to fill this gap. However, the effectiveness of these programs in bridging the practical industry requirements needs evaluation.
- **Enhanced Safety and Security Features:** As drones become more prevalent, safety and security concerns must be addressed. In response, drone manufacturers are incorporating advanced safety features, such as obstacle avoidance systems, geofencing, and remote identification capabilities. These innovations will help ensure the safe integration of drones into the airspace and mitigate potential risks associated with their operation.
- **Proliferation of Counter-Drone Solutions:** As drones become more widespread, the need for counter-drone solutions to protect sensitive locations and prevent unauthorized drone use is growing. These systems can detect, track, and mitigate potential drone threats, ensuring the safety and security of critical infrastructure, events, and airspace.
- **Cyber threat of drones:** As technological innovations in the field of drones advance, some reports analyze and explore the security implications of the rapid growth in UAS technology, focusing specifically on current vulnerabilities and future trends. Cybersecurity aspects need to be considered in the designing of drones. Coherent, up-to-date cybersecurity strategies are required (Rand Corporate, 2020). On the one hand, it is required to ensure the safety of unmanned aerial vehicles integration into the national airspace, and on the other hand, not to strangle the promising industry with excessive control. The Global Drone Regulations Database provides an overview of the unmanned aerial vehicles regulations around the world (Kaputsina et al. 2021).

3.4 T.2.1.1.3 Identifying theoretical and/or practical gaps between the educational use of drones and drone industry.

After critically reviewing and reflecting the educational use, topics, benefits and challenges of drones, as well as reviewing the industrial and technological trends, we elaborate on the theoretical and practical gaps that need to be addressed, based on our observations and discussions.

1. Knowledge about regulations and compliance

Industry demands professionals who understand and can navigate the intricate web of drone regulations, including airspace restrictions, licensing, and safety protocols. As the technology evolves rapidly, regulations adjust accordingly. Educational materials focus on theoretical aspects of drone technology, and might use them to add interactivity and interest in a lecture, without adequately covering the complex and evolving regulations that govern drone operations. This includes a detailed understanding of international standards, such as the regulations established by the International Civil Aviation Organization (ICAO) and the European Union Aviation Safety Agency (EASA), which set the framework for drone operations globally and within the EU, respectively. Additionally, given the dynamic nature of this field, there is a pressing need for educational programs to incorporate case studies and examples of how regulations have adapted to new drone technologies and applications. This approach ensures that learners are not only aware of current laws but are also prepared to anticipate and adapt to future regulatory changes.

2. Hands-on technical skills

While educational materials may provide theoretical knowledge about drone technology, there might be insufficient emphasis on practical skills like drone piloting, maintenance, sensor calibration, and data collection. The industry requires professionals who can operate and troubleshoot drones effectively, demonstrating hands-on skills beyond theoretical understanding. This includes the development of lab-based modules and interactive workshops where students can gain practical experience in drone piloting, routine maintenance, sensor calibration, and real-time data collection.

3. Real-world applications

Educational materials may lack in-depth exploration of real-world applications of drones across various industries, such as agriculture, mapping, environmental monitoring, and disaster response. Although there is research about the use of drones in various skills, more evidence is required about the actual implementation and application of drones in the real world. Industry demands professionals who can apply drone technology creatively to solve practical problems in diverse fields, showcasing adaptability and problem-solving skills. Therefore, educational material and courses should encourage learners to explore potential future applications of drones in the real world, for the purpose of solving real world problems. Creativity and critical thinking are required and should be incorporated into the curricula.

4. Data Analysis and Interpretation

Educational materials might focus on data collection through drones, but may not delve into data analysis techniques and tools required to extract meaningful insights from collected data. Industry requires professionals who can process, analyze, and interpret data obtained from drones to make informed decisions and recommendations. Furthermore, understanding that the value of drone technology extends far beyond mere data collection, there is a need for new curriculum that includes comprehensive training in data analytics software and techniques. This should encompass the use of AI and machine learning algorithms for processing large datasets, spatial analysis skills for geographic data interpretation, and advanced visualisation tools for presenting actionable insights.

5. Interdisciplinary Knowledge

Drone education might lack integration with related disciplines like GIS (Geographic Information Systems), remote sensing, software development, and engineering. Industry values professionals who can collaborate across disciplines, combining drone technology with other tools to address complex challenges.

6. Communication and Collaboration

As mentioned above, inter-disciplinary knowledge is essential for professionals. Interdisciplinary knowledge requires soft skills, such as communication collaboration, and teamwork. This is a topic which is discussed among educators globally and it concerns not only drone education, but education on the whole. Today's professionals require soft skills in order to solve real-world problems and collaborate with other professionals. New curricula developers and course directors should take this into account when updating the curricula. Specifically for drone education, it might not focus on communication skills, teamwork, and collaboration necessary to effectively convey drone-related information to non-technical stakeholders. Industry values professionals who can communicate findings, recommendations, and insights to diverse audiences, facilitating productive collaborations.

7. Ethical and Privacy Considerations

Educational materials might not thoroughly cover the ethical implications of drone use, such as privacy concerns, data security, and potential misuse. This is especially important for industrial applications, as industry demands professionals who are ethically conscious and well-versed in ensuring responsible drone operations, especially in sensitive areas. The integration of dedicated modules that address the complexities of privacy rights, data security, and the ethical use of drones is essential. These modules should cover topics such as the ethical implications of aerial surveillance, the importance of data protection and confidentiality, especially when operating in sensitive areas, and the societal impact of drone technology. By incorporating case studies and ethical dilemmas, learners can better understand the real-world consequences of their actions and decisions when using drones.

8. Emerging Technologies and Trends

Educational materials might not keep pace with rapidly evolving drone technologies, such as AI integration, advanced sensors, swarm technology, and urban air mobility. Courses involving drones need to adapt to the rapidly evolving technological advancements, and ensure that the technologies and the material are up-to-date. Industry requires professionals who are prepared to adopt and adapt to emerging technologies, staying at the forefront of innovation. In conclusion, the regular updating of course materials to include the latest advancements in drone technology, such as artificial intelligence (AI) integration for autonomous flights, the use of advanced sensors for enhanced data collection, the development of swarm drone technology for coordinated operations, and the exploration of urban air mobility solutions is necessary.

4. T2.1.2 Background research about the lack of practical/lab materials in order to fully understand the continues needs of the drone technology and deployments

Drone technology is rapidly evolving, with new advancements in autonomy, battery life, sensor quality, and communication systems being developed constantly. This fast pace makes it challenging for educational materials and lab resources to stay current. The gap between the technology available in the market and the technology discussed in educational settings can widen quickly, leaving students and professionals with outdated knowledge. Furthermore, the regulatory framework for drone operations is complex and varies significantly by region. Changes in regulations can impact how drones are used and what technologies are emphasized. Keeping educational materials up-to-date with these changes is challenging but essential for preparing students for real-world applications. Within Drones4Green project we present how drones play a significant role in the green industry, from monitoring deforestation and wildlife to managing renewable energy infrastructure. However, the specific requirements and applications of drones in these areas may not be properly covered in general drone technology education. Specialized training materials focusing on ecological monitoring, precision agriculture, and renewable energy inspection are needed but often lacking.

The hands-on experience is important for understanding the potential of drone technology. However, there is a significant barrier in terms of access to drones, sensors, and related technologies for practical training. The cost of equipment, maintenance, and the need for safe, legal flying spaces limit the ability of educational institutions to offer comprehensive hands-on learning experiences. Furthermore, there's an absence of a standardized curriculum for drone technology education. This lack of standardization can lead to gaps in knowledge and skills among learners, making it difficult for employers in the green industry and beyond to assess the qualifications of job applicants.

Within this task we have conducted a review of the literature in order to classify the lack of practical/lab materials and to fully understand the continued needs of the drone technology and deployments.

As we mentioned before the integration of drone technology into the green industry has highlighted a critical gap between the advancements in drone capabilities and the existing educational curriculum designed to prepare students for this field. Our literature review highlights the complexities of drone technology education as well as the challenges and proposing solutions to bridge the educational gap that will be introduced later in the project in A2.2.

As drone technology has seen advancements in recent years, with significant improvements in autonomy, sensor capabilities, and battery life, these technological strides have alerted the development and updating of educational materials, leading to a curriculum that often lags behind the latest industry developments. The literature points to the need for educational institutions to rapidly integrate new technologies and applications into their offerings to ensure graduates are well-prepared for the workforce.

In the following table we summarize the technological advancements in drone technology, their impact on education, and recommendations for curriculum development to inform further the activities in WP2:

Table 1: Technological advancements in the drone technology

Technological Advancement	Impact on Education	Recommendation
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Autonomy	Curriculum lacks content on autonomous drone navigation and decision-making processes.	Integrate modules on AI and machine learning for drone navigation.
Sensor Capabilities	Educational materials do not cover the latest advancements in imaging, thermal, and multispectral sensors.	Update curriculum with latest sensor technologies and their applications in various industries.
Battery Life	Teaching resources fail to address the extended operational times and charging technologies.	Incorporate lessons on power management and the impact of battery technology on mission planning.

Moreover, another finding from the literature review is the regulatory framework, as it was mentioned before for drone operations that is both complex and dynamic. This evolving regulatory environment highlights a challenge for educators, who must keep curriculum content current to prepare students for legal and safe drone operation in various occasions. The literature suggests a pressing need for curriculum developers to incorporate ongoing regulatory changes into their materials, ensuring students understand the legal context of drone use.

The following table reflects the regulatory aspects of drone operations, their impact on education, and recommendations for curriculum development:

Table 2: regulatory aspects of drone operations

Regulatory Aspect	Impact on Education	Recommendation
Evolving Regulations	Curriculum does not reflect the latest drone operation regulations.	Regularly update courses with the latest regulatory changes and case studies.
Jurisdictional Variance	Lack of coverage on how regulations vary by region and impact drone use.	Include comparative studies of drone laws across different jurisdictions.
Societal Norms	Educational materials are outdated with respect to societal expectations and norms for drone use.	Integrate discussions on ethical drone use and societal impact into the curriculum.

Furthermore, the application of drones within the green industry, including tasks such as environmental monitoring, precision agriculture, and renewable energy infrastructure management, demands specialized knowledge and skills. However, our review indicates a shortfall in educational programs specifically tailored to these applications. There exists a significant opportunity for curriculum development focused on the intersection of drone technology and environmental sustainability, addressing the unique needs of the green industry.

The following table summarizing the applications of drones within the green industry, their impact on education, and recommendations for curriculum development:

Table 3: applications of drones within the green industry

Drone Application	Impact on Education	Recommendation
Environmental Monitoring	Lack of specialized training on using drones for environmental data collection and analysis.	Develop modules on environmental science applications of drones, including data collection and ecosystem health assessment.
Precision Agriculture	Educational programs often omit the use of drones for crop monitoring, health assessment, and targeted interventions.	Integrate precision agriculture techniques using drones into agricultural and environmental science curricula.
Renewable Energy Management	Courses fail to adequately cover the use of drones in inspecting and managing renewable energy infrastructure.	Create specialized courses on the use of drones for renewable energy infrastructure inspection and management.

Finally, access to hands-on experience is critical for a comprehensive understanding of drone technology. Yet, the literature reveals barriers, including the cost of drones and related technologies, and the availability of safe, legal spaces for flight training. These challenges limit the practical training opportunities available to students, a crucial component of effective learning in this field. In addition, the interdisciplinary nature of drone technology education, which includes computer science, engineering, environmental science, and policy, further complicates curriculum development. The literature points out the importance for an integrated approach to education that encompasses

the technical, environmental, societal, and regulatory aspects of drone use, providing students with a holistic understanding of the field. Also, a recurring theme in the literature is the lack of a standardized curriculum in drone technology education, leading to inconsistencies in the knowledge and skills imparted to students across different programs. This variability hinders the ability of employers to assess the qualifications of job applicants effectively, particularly in specialized fields within the green industry.

The following table presents the challenges of providing hands-on experience, the interdisciplinary nature of drone technology education, and the lack of a standardized curriculum, including their impacts on education and corresponding recommendations:

Table 4: applications of drones within the green industry

Aspect	Impact	Recommendation
Hands-on Experience: Cost	High costs limit access to necessary drones and technology for practical training.	Increase investment in drones and technology and explore rental or sharing arrangements.
Hands-on Experience: Legal Spaces	Lack of safe, legal spaces for flight training restricts hands-on learning opportunities.	Collaborate with local governments or private entities to secure legal flying spaces for training.
Interdisciplinary: Computer Science	Curricula often lack comprehensive computer science components relevant to drone technology.	Incorporate advanced computer science topics, including AI and machine learning for drone navigation.
Interdisciplinary: Engineering	Engineering aspects of drones, such as design and mechanics, are not fully integrated into many programs.	Strengthen engineering curriculum to include drone design, aerodynamics, and material science.

<p>Interdisciplinary: Environmental Science</p>	<p>The environmental applications of drones are not adequately covered in many educational settings.</p>	<p>Integrate environmental science modules focusing on drone use in monitoring and conservation.</p>
<p>Interdisciplinary: Policy</p>	<p>Drone policy and regulation, crucial for legal operations, are often underemphasized in curricula.</p>	<p>Expand curriculum to include comprehensive study of drone laws, ethics, and societal impacts.</p>
<p>Standardization: Curriculum Consistency</p>	<p>Variability in drone education curricula across institutions leads to uneven preparation of graduates.</p>	<p>Establish national or international standards for drone technology education to ensure quality and consistency.</p>

Conclusion:

By working collaboratively and focusing on innovative solutions, we can bridge this gap and pave the way for a future where drones can truly revolutionize diverse sectors. The lack of practical and lab materials presents a significant hurdle for drone technology development and deployment. By addressing this gap through the proposed solutions, we can unlock the full potential of this transformative technology and ensure its responsible and inclusive advancement for the benefit of society.

5. T2.1.3 Information gathering and evaluation based on the consortium partner experiences and expertise

This task aimed to collect data about the experiences and the expertise of the partners, regarding the application of drones. All partners contributed to collect information about the group experience. The results of the survey are presented below.

Do you have experience in drone solutions?

12 responses

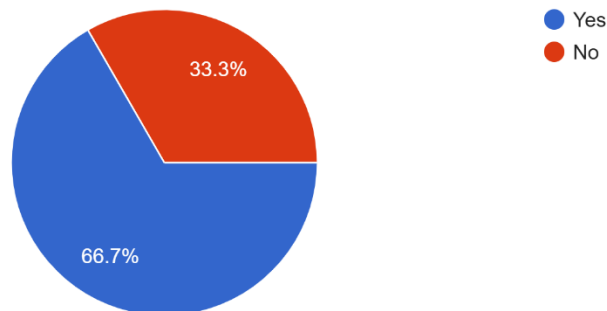


Figure 1: The experience of the partners with the drones

The experiences of the partners were collected with open-ended question. Analyzing the results it is evident that the consortium brings together a diverse and well-balanced range of expertise, ensuring a comprehensive approach to achieving the project's objectives. Members contribute specialized knowledge in fields such as electronics, semiconductors, and digital systems, alongside advanced competencies in drone operations, including LiDAR and photogrammetry, and renewable energy solutions. The group also boasts experience in cybersecurity, project management, and cutting-edge developments in Artificial Intelligence (AI) and Explainable AI (XAI). Notably, practical applications, such as using drones for energy loss assessments in buildings and software development, are complemented by academic research in neurocomputing and AI systems within leading laboratories. This multidisciplinary expertise positions the consortium to address both technical and practical challenges effectively, fostering innovative and sustainable outcomes.

Regarding how many years the consortium has experience with drones, the consortium members answered that they have an average of approximately 2.9 years of experience in drone-related fields. Out

of the 12 contributors, 8 have relevant expertise, showcasing a balanced mix of seasoned professionals and emerging contributors. This diversity enriches the consortium's ability to address both technical and practical challenges in the project.

However, in the question about specific experience with drones education, only two partners responded positively. This implies that the consortium has a wide range of experiences with drones, including two partners with prior experiences in drones for education.

Finally, the responses highlight several best practices for drones that can inform the drone deployment framework. Key recommendations include ensuring compliance with national and local aviation regulations, such as adhering to altitude restrictions and maintaining regulatory alignment across regions. Practical applications emphasized include image processing, extracting geometry of roofs and facades, and using drones for surveying renewable energy sources and terrains affected by disasters like fires or earthquakes. Additional practices focus on advanced flight planning, safety precautions, and effective team organization to optimize operations. These insights underscore the importance of both technical precision and organizational efficiency in deploying drones effectively.

6. T2.1.4 Design a Drone Deployment Framework for the adoption of Drone technology in an expanded set of industry domains and applications considering the perspective of green business solutions

Based on the experience acquired from the previous activities, and from the consortium's expertise, the drones deployment framework consists of 9 categories. By focusing on sustainability, regulatory compliance, practical training, and interdisciplinary knowledge, the framework aims to promote the responsible and innovative use of drone technology across various industries. Through collaboration and continuous improvement, this framework will support the growth of green business solutions and the advancement of drone technology in a sustainable and impactful manner.

The comprehensive Drone Deployment Framework consists of 9 key categories, each focusing on different aspects essential for the successful adoption of drone technology across various industry domains while considering green business solutions. A summary of the framework categories is provided below:

- **Assessment and Planning**
 - Industry Analysis
 - Needs Assessment
 - Stakeholder Engagement
 - Educational Integration

- **Technology Selection**
 - Drone Type Selection
 - Green Technology
 - Sensor Integration
 - AI and Machine Learning

- **Regulatory Compliance**
 - Understanding Regulations

 - Compliance Training

 - Certification and Licensing

- **Operational Framework**
 - Pilot Programs

 - Data Collection

 - Training and Education

- Workshops and Labs

 - **Sustainability Integration**
 - Energy Efficiency
 - Renewable Energy
 - Battery Management
 - Waste Management
 - Sustainable Materials

 - **Data Management and Analytics**
 - Data Collection
 - Real-Time Analysis
 - Advanced Analytics
 - Decision-Making Support

 - **Applications and Use Cases**
 - Agriculture
 - Logistics
 - Construction
 - Environmental Monitoring
 - Energy
 - Education

 - **Evaluation and Reporting**
 - Performance Metrics
 - KPI Development
 - Continuous Improvement
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- Environmental Reporting
- Stakeholder Communication

- **Scalability and Expansion**
 - Scaling Operations
 - Phased Expansion
 - Resource Allocation
 - Innovation and R&D
 - Research Investment
 - Partnerships
 - Standardization and Best Practices

- **Assessment and Planning**
 - Identified Industry Domains: Agriculture, logistics, construction, environmental monitoring, energy, and education.
 - Needs Assessment: Detailed analysis of specific industry challenges and potential drone applications to address them.
 - Stakeholder Engagement: Industry experts, environmental scientists, regulatory bodies, and educational institutions.

- **Educational Integration:**
 - Curriculum Development: Design interdisciplinary curricula that integrate drone technology with environmental science, engineering, computer science, and policy studies.
 - Training Programs: Develop comprehensive training programs for educators and students focusing on practical skills and regulatory knowledge.

- **Technology Selection**

- Industry-Specific Drones: Drones should be chosen based on industry-specific needs, such as payload capacity, flight duration, and sensor requirements.
- Green Technology: Prioritize electric drones with efficient battery systems and explore renewable energy options like solar charging.

- **Sensor Integration:**

- Advanced Sensors: Integrated multispectral, thermal, and high-resolution cameras tailored to industry applications.
- AI and Machine Learning: Implement AI-driven sensors for autonomous operations and advanced data analytics.

- **Regulatory Compliance**


- Global Standards: Educate on international regulations (ICAO, EASA) and local regulations.
- Compliance Training: Develop training modules focusing on navigating and complying with complex regulatory frameworks.

- **Certification and Licensing:**

- Operator Certification: Ensure drone operators are certified and familiar with safety protocols and regulations.
- Drone Registration: Register drones with relevant authorities and ensure they meet regulatory standards.

- **Operational Framework**

Pilot Programs:

- Test Deployments: Launch pilot programs in various industries to evaluate drone performance and environmental impact.
 - Data Collection: Use pilots to collect data on efficiency, cost-effectiveness, and sustainability.
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- **Training and Education:**

- Practical Training: Provide hands-on training for students and professionals in drone piloting, maintenance, and data analysis.
- Workshops and Labs: Establish labs and workshops to offer real-world drone operation experiences.

- **Sustainability Integration**

- Renewable Energy: Utilize solar-powered charging stations and energy-efficient drones to reduce carbon footprint.
- Battery Management: Implement efficient battery management practices to extend drone operational life.

- **Waste Management:**

- Recycling Programs: Develop recycling programs for drone components and batteries.
- Sustainable Materials: Use drones built with sustainable and recyclable materials.

- **Data Management and Analytics**

- High-Resolution Data: Use drones to collect detailed data for environmental monitoring, agriculture, and infrastructure management.
- Real-Time Analysis: Implement real-time data processing and analytics for immediate insights.

- **Data Interpretation:**

- Advanced Analytics: Train professionals in data analysis techniques using AI and machine learning.
- Decision-Making Support: Provide tools and training for interpreting drone-collected data to make informed decisions.

- **Applications and Use Cases**

- Precision Farming: Use drones for crop health monitoring, soil analysis, and irrigation management to promote sustainable agriculture.
 - Yield Optimization: Implement drone technology to optimize crop yields and reduce resource usage.
 - **Logistics:**
 - Last-Mile Delivery: Deploy drones for efficient last-mile delivery to reduce emissions and improve logistics efficiency.
 - Inventory Management: Use drones for inventory tracking and management in large warehouses.
 - **Construction:**
 - Site Monitoring: Employ drones for site surveys, progress monitoring, and safety inspections to minimize environmental disruption.
 - 3D Mapping: Use drones for creating detailed 3D maps and models of construction sites.
 - **Environmental Monitoring:**
 - Wildlife Conservation: Monitor wildlife populations and habitats using drones to support conservation efforts.
 - Pollution Tracking: Use drones to assess air and water quality and track pollution sources.
 - **Energy:**
 - Infrastructure Inspection: Deploy drones to inspect renewable energy installations, such as solar panels and wind turbines.
 - Maintenance Planning: Use drone data for predictive maintenance and to enhance the efficiency of energy infrastructure.
 - **Education:**
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- STEM Programs: Integrate drones into STEM education to teach concepts related to aerodynamics, programming, and environmental science.
 - Interdisciplinary Projects: Encourage projects that combine drone technology with environmental studies, engineering, and data science.
- **Evaluation and Reporting**
- KPI Development: Establish KPIs to evaluate the effectiveness of drone operations and their environmental impact.
 - Continuous Improvement: Use data-driven insights to continuously improve drone deployment strategies.
- **Environmental Reporting:**
- Regular Reports: Produce regular reports on environmental performance, highlighting achievements and areas for improvement.
 - Stakeholder Communication: Maintain transparent communication with stakeholders about the environmental benefits and challenges of drone operations.
- **Scalability and Expansion**
- Phased Expansion: Gradually scale drone operations based on successful pilot outcomes and stakeholder feedback.
 - Resource Allocation: Allocate resources efficiently to support expansion without compromising sustainability.
- **Innovation and R&D:**
- Research Investment: Invest in research and development to explore new drone technologies and applications.
 - Partnerships: Form partnerships with technology providers, research institutions, and environmental organizations to drive innovation.

- **Standardization and Best Practices:**

- Curriculum Standardization: Establish national or international standards for drone technology education to ensure quality and consistency.
- Best Practices Sharing: Create platforms for sharing best practices and lessons learned across industries and educational institutions.

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