

AVICO

# CODING TRAINING WITH AVIATION TECHNOLOGIES

## Coding Skills and Training Information KIT



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# Content

- Introduction ..... 4**
  - Overview of the AVICO Project..... 4
  - Purpose of the VET Guide ..... 5
  
- 1 Context and Rationale..... 7**
  - 1.1 Why Combine UAVs with Coding? ..... 7
  - 1.2 Target Audience ..... 8
  
- 2 Literacy Review..... 9**
  
- 3 Key Findings..... 9**
  - 3.1 Unmanned Aerial Vehicles and Their Applications..... 9
  - 3.2 Defining Essential Skills..... 10
  - 3.3 Conclusions ..... 10
  
- 4 Project Methodology ..... 11**
  - 4.1 Data Collection..... 11
  - 4.2 Analysis of Findings..... 11
  
- 5 National Insights from Partner Countries..... 12**
  - 5.1 Key Findings ..... 12
  - 5.2 Challenges and Strategies by Country ..... 12
  - 5.3 Technical Barriers..... 15
  - 5.4 Student Engagement and Motivation..... 17
  - 5.5 Effective Teaching Methods ..... 20
  
- 6 Competency Framework ..... 22**
  - 6.1 Competency Descriptions ..... 22
  - 6.2 Core Competencies for Coding and UAV Skills ..... 25
  - 6.3 Recommendations ..... 26
  
- 1 Didactic Framework ..... 29**
  - 1.1 Didactic Principles ..... 29
  
- 2 Educational Approaches..... 30**
  - 2.1 Teaching and Learning Methods ..... 31
  
- 3 Key Indicators for Learning and Skill Development ..... 32**
  - 3.1 Performance Indicators ..... 33



3.2 Outcome Metrics .....	33
3.3 Didactic Support for Educators .....	34
3.4 Learning Environment and Classroom Management .....	34
<b>4 Templates for Didactic Resources .....</b>	<b>35</b>
4.1 Lesson Plan Templates .....	35
4.2 Assessment Rubrics .....	36
4.3 Safety and Compliance Checklists .....	36
4.4 Links to Recommended Tutorials, Software and Literature .....	36
<b>5 Conclusion .....</b>	<b>36</b>



# Introduction

## Overview of the AVICO Project

The **AVICO project – Coding Training with Aviation Technologies** – is an Erasmus+ Cooperation Partnership in vocational education and training focused on strengthening the connection between **digital skills development, coding education and unmanned aerial vehicle (UAV) technologies**. The project was created in response to a clear educational and labour-market need: while UAVs are rapidly expanding across sectors such as agriculture, logistics, environmental monitoring, construction, media, security and public services, vocational education systems often still lack structured, practice-oriented learning pathways that combine drone technologies with coding and computational thinking. AVICO addresses this gap by developing educational resources and methodologies that help vocational learners move beyond basic drone awareness towards a more integrated understanding of how UAVs can be operated, programmed and used in professional contexts.

The project brings together partner organisations from **Slovakia, Croatia, Serbia, Portugal, Turkey and Italy**, combining expertise from vocational education, higher education, technology-oriented institutions and organisations experienced in training development and innovation. This transnational structure allows the project to compare national contexts, identify common challenges and produce results that are both evidence-based and adaptable across countries. From the beginning, AVICO was conceived not only as a content-development project, but as a collaborative effort to modernise vocational education through **digital transformation, innovative teaching methods, interdisciplinary learning and stronger links between education and labour-market needs**.

A central feature of AVICO is its step-by-step development logic. The project first investigates the educational, technological and methodological context through literature review, interviews, student surveys and national reporting. These findings are then translated into a structured information base for curriculum planning, didactic design and competency development. On this basis, the partnership develops curriculum content, open educational resources, simulation-based support tools and a MOOC environment that allow UAV and coding education to be delivered in a more accessible, practical and engaging way. In this sense, AVICO is not limited to producing isolated learning materials; it seeks to build a coherent educational ecosystem in which research, pedagogy, digital tools and learner needs are meaningfully connected.

The innovation of the project lies in the combination of **coding as a transversal digital competence** with **aviation technologies as an attractive and application-oriented learning context**. UAVs are particularly suitable for vocational education because they connect hardware, software, automation, data collection, safety requirements and real-world problem-solving. By introducing learners to both drone-related knowledge and coding logic, AVICO supports the development of technical skills, analytical thinking, creativity and adaptability. This is especially important in a labour market where digital readiness, interdisciplinary competence and the ability to work with emerging technologies are



becoming increasingly valuable.

The project also reflects wider European priorities in vocational education, especially the need to strengthen **digital readiness, innovation, resilience and lifelong learning opportunities**. AVICO contributes to these priorities by designing results that are open, multilingual and reusable, and by supporting educators and institutions in updating their teaching approaches in line with current technological developments. Its outputs are intended not only for project partners, but also for a broader community of VET providers, educators, learners, career guidance actors and stakeholders interested in the future of digital and technology-enhanced vocational training.

## Purpose of the VET Guide

The **AVICO VET Guide** has been developed as a foundational document to support the integration of UAV technologies and coding education into vocational education and training. Its purpose is to provide educators, trainers, curriculum developers, institutions and other relevant stakeholders with a **clear, evidence-based and practice-oriented framework** that helps translate the project's research findings into educational action. Rather than serving only as a descriptive report, the guide is intended to function as a bridge between research, pedagogy and implementation. It explains why UAVs and coding should be combined, what competences are needed, which challenges need to be addressed, and how learning can be organised in a way that is meaningful, gradual and relevant to learners' future professional pathways.

The guide is based on the first cycle of AVICO activities, including the literature review, interview methodology, expert interviews, student surveys and transnational analysis. As such, it reflects both **research evidence and stakeholder perspectives**. It captures the main educational needs identified across partner countries: the demand for more modernised VET content, stronger integration of digital competences, better educator preparedness, more engaging and applied teaching methods, and closer alignment with the evolving needs of industry. By synthesising these findings into one structured document, the guide offers a shared point of reference for all later project outputs, especially the curriculum, open educational resources, MOOC content and practical experimentation phases.

A key function of the VET Guide is to define the **competency logic** behind the AVICO approach. It helps clarify which technical, analytical and transversal competences are relevant when combining UAV training with coding education, and how these competences can be developed progressively. This includes not only foundational knowledge of UAV systems and introductory coding, but also broader learning dimensions such as problem-solving, teamwork, critical thinking, digital confidence and the ability to apply technology in context. In this respect, the guide supports a competence-oriented view of vocational education, in which students do not merely acquire isolated knowledge, but build structured abilities that can be transferred to real tasks and professional settings.

The VET Guide also serves a didactic purpose. It is designed to help educators understand which teaching principles and methods are most suitable for this field, including student-centred learning, experiential learning, project-based work, simulation, blended learning and step-by-step progression from basic to more advanced tasks. Because UAV and coding education can be demanding in terms of infrastructure, confidence and pedagogy, the guide



aims to reduce uncertainty for teachers and institutions by offering a structured entry point. It provides a common language and an educational rationale that can later be translated into lesson planning, classroom management, assessment and digital resource development.

Finally, the purpose of the VET Guide is to support **transferability and sustainability**. AVICO operates across different national contexts, institutional settings and levels of readiness. The guide therefore does not prescribe a single rigid model, but offers a framework that is standardised in its core logic and flexible in its application. This makes it useful both for institutions already working with drone-related technologies and for those that are only beginning to explore this area. In this way, the guide contributes to the wider ambition of the AVICO project: to support more inclusive, innovative and future-oriented vocational education that prepares learners for the realities of a digitally transformed labour market.



# PART A

## 1 Context and Rationale

The AVICO project was developed in response to a visible mismatch between the pace of technological change and the readiness of vocational education systems to prepare learners for emerging digital professions. Unmanned Aerial Vehicles (UAVs) are no longer niche tools used only in specialised aviation settings. They are becoming part of everyday practice in sectors such as agriculture, logistics, environmental monitoring, infrastructure inspection, tourism, public governance and safety-related services. At the same time, the growing functionality of UAVs increasingly depends on software, automation, data processing and programmable logic. This means that future professionals need more than operational familiarity with drones; they need a combination of technical, digital and problem-solving competences that allow them to use, adapt and further develop these technologies in real working environments.

Research carried out within AVICO confirmed that this educational need is real and shared across partner countries. The transnational findings showed strong interest in UAV-related learning, but also highlighted several structural gaps: insufficient curriculum integration, limited access to equipment and infrastructure, uneven educator preparedness, and a lack of structured methods for combining coding with UAV practice. At the same time, both students and experts pointed to the importance of practical learning, project-based approaches, simulation tools and stronger cooperation with industry. These findings created a strong rationale for developing a dedicated VET framework that connects technological relevance with didactic usability.

The rationale for AVICO is therefore both educational and economic. From an educational perspective, vocational institutions need more future-oriented and interdisciplinary learning models that reflect the realities of digital transformation. From a labour-market perspective, there is increasing demand for graduates who can work with UAV systems not only as users, but also as informed operators capable of understanding coding logic, mission planning, automation and data-based decision-making. The AVICO VET Guide responds to this need by offering a structured basis for modernising vocational education in a way that is practical, competence-oriented and adaptable across countries and institutional contexts.

### 1.1 Why Combine UAVs with Coding?

The AVICO project was developed in response to a visible mismatch between the pace of technological change and the readiness of vocational education systems to prepare learners for emerging digital professions. Unmanned Aerial Vehicles (UAVs) are no longer niche tools used only in specialised aviation settings. They are becoming part of everyday practice in sectors such as agriculture, logistics, environmental monitoring, infrastructure inspection, tourism, public governance and safety-related services. At the same time, the growing functionality of UAVs increasingly depends on software, automation, data processing and programmable logic. This means that future professionals need more than operational



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## 1.2 Target Audience

The AVICO VET Guide is designed primarily for **vocational educators, trainers and curriculum developers** who are involved in preparing learners for technology-oriented professions. It is especially relevant for teachers and training staff in technical schools, vocational institutes, training centres and other organisations that want to modernise their educational offer by introducing UAV technologies, coding and more practice-oriented digital learning methods. For these users, the guide serves as both a conceptual reference and a practical support tool for planning, adapting and delivering learning activities.

A second important target group consists of **students and learners in vocational education**, particularly those in secondary VET, technical training pathways and related applied learning environments. The AVICO approach is designed to help these learners build relevant digital, technical and transversal competences in a way that is engaging, future-oriented and connected to real applications. The guide itself is not written only for students, but it is intended to improve the quality and relevance of their learning experience by helping educators create training that responds to current labour-market developments.

The guide also addresses **institutional and systemic stakeholders**, including school leaders, education managers, policymakers, career guidance actors, training consultants and organisations involved in lifelong learning or educational innovation. For these users, the guide offers a structured framework for curriculum renewal, competence development and institutional planning in areas where drone technologies and coding are becoming increasingly relevant. It may also be useful for **industry partners and external experts** who cooperate with VET providers and want to support stronger alignment between education and professional practice.



In a broader sense, the target audience of the guide includes all stakeholders interested in more innovative, inclusive and digitally relevant vocational education. This is particularly important in contexts where institutions are only beginning to explore UAV-related training and need a clear entry point. The guide therefore aims to be both specialised enough to be meaningful and flexible enough to be adapted across different national, institutional and sectoral settings.

## 1.3 Literacy Review

To establish a robust foundation for the project, a comprehensive literature review was conducted by two key scientific partners: *the Slovak University of Agriculture in Nitra* and the *Veleučiliste u Sibeniku*. This review plays a pivotal role in identifying the current state of UAV technologies, coding education methodologies, and their applications in various industries. The need for a detailed literature review arose from the rapid expansion of UAV technologies across sectors like agriculture, logistics, tourism, and public governance, where coding skills are essential for managing and optimizing these advanced systems. By synthesizing existing research, the review provides a clear understanding of the challenges, opportunities, and skill gaps in integrating UAV and coding education into vocational training. It also aligns with European educational policies that emphasize digital literacy, innovation, and the development of technical competencies to meet the demands of a technology-driven workforce.

The document outlines the motivation for integrating coding into UAV training, the essential skills required for UAV operations, and the barriers to implementation in vocational education contexts. Key areas explored include the applications of UAVs across industries, the programming proficiency needed for their operation, and successful models for transferring coding skills into UAV training. Additionally, the review examines the challenges of aligning theoretical knowledge with practical applications and highlights the importance of interdisciplinary approaches in achieving educational objectives.

## 2 Key Findings

### 2.1 Unmanned Aerial Vehicles and Their Applications

The literature review highlights the diverse applications of UAV technologies across various industries. In agriculture, UAVs are utilized for precision farming, crop monitoring, and pest control, optimizing efficiency and reducing costs. In logistics, they enhance delivery systems and supply chain management, while in tourism, they provide unique aerial perspectives for marketing and exploration. Public governance sectors, such as disaster management and infrastructure inspection, benefit from the versatility of UAVs in accessing remote or hazardous areas. These findings underscore the importance of equipping students with practical knowledge of UAV operations to meet the growing demand for skilled professionals



in these fields.

## **2.2 Defining Essential Skills**

Essential skills for UAV operation include technical proficiency in drone piloting, knowledge of aviation regulations, and the ability to analyze and process data collected through UAV systems. Additionally, soft skills like problem-solving, teamwork, and adaptability are crucial for addressing real-world challenges in UAV-related projects. The review emphasizes that coding is integral to UAV operation, as programming is required for tasks such as autonomous navigation, sensor integration, and mission planning. Developing these skills through vocational education ensures that students are prepared to meet industry demands.

### **2.2.1 Integration of Coding into UAV Training**

The integration of coding into UAV training is vital for enhancing the functionality and efficiency of drone operations. The literature review identifies successful models that combine theoretical coding knowledge with hands-on drone programming. These models often include project-based learning, where students create and execute drone missions, and the use of simulation tools to practice coding in a controlled environment. The review also highlights the importance of block-based programming for beginners, transitioning to text-based programming languages like Python or JavaScript as students' progress. This gradual approach ensures a solid foundation in coding and its applications in UAV technologies.

### **2.2.2 Analysis of Research**

The review analyzed existing research on UAV and coding education to identify gaps and opportunities. It found that while UAV technologies are increasingly integrated into vocational training, many programs lack a structured approach to teaching coding skills in conjunction with drone operations. Challenges such as limited resources, insufficient training for educators, and safety concerns during practical UAV activities were frequently cited. However, the review also identified best practices, including industry collaborations, interdisciplinary approaches, and the use of innovative teaching tools. These insights provide a roadmap for addressing gaps and enhancing the effectiveness of UAV and coding education.

## **2.3 Conclusions**

Integration of coding into UAV applications requires a diverse set of skills that extend beyond basic programming. These skills include digital literacy, programming proficiency, system integration, data analysis, and problem-solving abilities. Each of these competencies is essential for the efficient development and operation of UAV systems, enabling their effective use across industries such as agriculture, logistics, tourism, and public sector governance. By mastering these skills, developers and operators can leverage UAV technology to enhance data collection, improve decision-making, and optimize various processes in different fields. As the demand for UAVs continues to grow, the importance of building these skill sets becomes even more critical, ensuring that UAV applications are carried out safely and



effectively in increasingly complex environments.

## 3 Project Methodology

The AVICO project employed a comprehensive methodology to integrate Unmanned Aerial Vehicle (UAV) technologies and coding education into vocational training. This methodology focused on three key areas: a literature review, data collection from students, and data collection from experts. Together, these components aimed to provide a well-rounded understanding of the challenges, opportunities, and strategies related to this innovative approach.

### 3.1 Data Collection

A detailed literature review was conducted by the Slovak University of Agriculture in Nitra (Slovakia) and the Veleučiliste u Sibeniku (Croatia). This review assessed existing research on UAV technologies, coding education, and their integration into vocational training. The review included topic clarification to identify the intersection of UAV applications and coding training, source selection using academic databases, and an analysis of trends, gaps, and best practices to guide the project's framework.

For expert interviews, semi-structured discussions were held with educators, vocational trainers, and industry professionals in participating countries. These interviews explored current practices, barriers, and innovative approaches to integrating UAV and coding education. The discussions covered pedagogical strategies, technical challenges, and the impact of these skills on employability.

Student surveys were designed to collect quantitative data on their familiarity with UAV technologies and programming, learning preferences, and perceived challenges. These surveys provided insights into students' knowledge, experience, and attitudes towards integrating these technologies into their training. Data were collected through accessible digital platforms to ensure broad participation.

### 3.2 Analysis of Findings

The analysis of findings in the AVICO project followed a multi-layered analytical approach to interpret data collected from the literature review, expert interviews, and student surveys. Each data source was analyzed using tailored methodologies to ensure accurate and actionable insights that aligned with the project's objectives.

The **literature review** was analyzed through thematic synthesis, focusing on identifying key trends, gaps, and best practices in UAV technologies and coding education. Information from academic articles and reports was categorized into thematic areas, such as skill requirements, educational methodologies, and industry applications. This provided a structured understanding of the field and served as a theoretical foundation for the project. The **expert interviews** were transcribed and analyzed using qualitative content analysis. Data was coded to identify recurring themes and patterns related to effective teaching methods, challenges, and strategies. Insights were grouped into categories such as barriers to implementation, successful practices, and recommendations for integrating UAV and coding education into



vocational training. This approach captured the lived experiences and professional insights of educators and industry professionals. The **student surveys** were analyzed using both quantitative and qualitative methods. Descriptive statistics provided an overview of demographics, levels of knowledge, and learning preferences, while qualitative analysis of open-ended responses identified common suggestions, challenges, and motivational factors. This combination ensured that both numerical trends and individual perspectives were incorporated into the findings.

Each project partner prepared and delivered a **national report** that included the analysis of the data collected through interviews with students and experts. These reports provided country-specific insights into the integration of UAV technologies and coding education in vocational training, reflecting the unique challenges, opportunities, and strategies in each partner country. Based on these national reports, a **transnational report** was prepared and published. This report synthesized the findings from all participating countries, offering a comprehensive overview of the project's results. It highlighted cross-country trends, best practices, and recommendations, ensuring a cohesive understanding of how UAV technologies and coding education can be effectively integrated across diverse educational and institutional contexts.

## 4 National Insights from Partner Countries

### 4.1 Key Findings

#### 4.1.1 Challenges and Strategies in Teaching UAV and Coding Skills

The AVICO project aims to enhance vocational education by incorporating UAV (Unmanned Aerial Vehicle) technology and coding skills. This innovative approach equips students with competencies increasingly relevant in aviation, agriculture, defense, fostering critical thinking, problem-solving, and technical proficiency. However, implementing this educational model poses unique challenges across participating countries, each facing its own logistical, institutional, and pedagogical hurdles.

In the partners' countries, Croatia, Portugal, Serbia, Slovakia, Turkey, and Italy, educators have encountered difficulties related to resource availability, infrastructure, regulatory standards, and students' foundational knowledge. Despite these obstacles, they have developed targeted strategies to create effective learning environments, ensuring students receive practical, high-quality education in UAV technology and coding. This section explores the specific challenges faced by each country within the AVICO framework and the strategies employed to support students' skill development in these crucial areas, ultimately contributing to a standardized yet adaptable educational approach across diverse contexts.

### 4.2 Challenges and Strategies by Country

#### 4.2.1 Croatia

In Croatia, one of the key challenges in teaching UAV and coding skills is keeping students



engaged. Many enter these courses with limited knowledge of coding and UAV operations, making it tough to spark and maintain their interest. Resource constraints further complicate this issue. Limited access to advanced UAV technology hinders hands-on learning, which is crucial for understanding and skill development. When students can't interact directly with drones and their coding mechanisms, it becomes difficult for them to relate theoretical concepts to practical applications. To tackle these challenges, Croatian educators have implemented a progressive learning model that enhances students' skills step by step. They begin with virtual tools and simulations, allowing students to understand UAV coding principles in a safe environment before moving on to real-world applications. This strategy not only builds confidence but also lays a strong foundation in both technical and operational skills. Additionally, Croatian educators prioritize collaborative projects that foster teamwork and collective problem-solving. By working together on project-based tasks, students share ideas and troubleshoot problems, making the learning experience dynamic and engaging. This method not only enhances comprehension but also makes learning more enjoyable.

### **4.2.2 Italy**

Educators in Italy faced significant obstacles in resource availability and infrastructure. Many schools lacked access to adequate UAV equipment, simulation tools, and up-to-date software, limiting the scope of hands-on training. Additionally, there was a noticeable skills gap among educators, many of whom had limited experience in both coding and UAV technologies, hindering effective curriculum delivery. Safety concerns, particularly in practical drone operations, posed logistical challenges, as schools had to ensure strict compliance with safety protocols. Another major challenge was engaging students in technical subjects like coding and UAV technology, especially those with limited foundational knowledge in programming. The complexity of integrating these topics into existing vocational curricula further complicated the process, requiring significant adjustments and alignment with educational standards. To address these challenges, schools and educators in Italy implemented several strategies. Partnerships with technology companies were established to secure resources such as drones and simulation tools, ensuring students had access to the necessary equipment for hands-on training. Professional development programs were organized to equip teachers with the technical skills and confidence needed to deliver high-quality coding and UAV education. Safety workshops and guidelines were developed to mitigate risks during practical drone operations, ensuring a safe learning environment. Educators adopted project-based learning approaches, integrating real-world applications into the curriculum to make lessons more engaging and relatable. Additionally, gamification techniques, such as coding competitions and interactive challenges, were used to increase student motivation and interest. The curriculum was gradually expanded to include basic block-based programming for beginners, progressing to more complex UAV-related applications, ensuring a smoother learning curve for students.

### **4.2.3 Portugal**

In Portugal, safety and regulatory compliance are pivotal when integrating UAV technology and coding into vocational training. With strict regulations governing drone usage, educators must ensure that students operate UAVs safely and responsibly, following national guidelines. Another significant challenge is student motivation and retention. Portuguese students often



find the technical demands of coding and UAV operations daunting, which can diminish their engagement, especially when they fail to see immediate, practical applications of these skills in their daily lives. To address these challenges, educators in Portugal adopt hands-on learning methods that prioritize interactive and applied experiences. By incorporating coding challenges and UAV simulations into the curriculum, they provide students with practical experience, making the content more relatable and engaging. Additionally, a strong focus on employability is crucial. Educators link the skills developed in UAV and coding courses to career pathways and job opportunities in high-demand sectors. By demonstrating the real-world applications and career potential of these skills, they aim to boost motivation, helping students view their education as a stepping stone to professional success.

#### **4.2.4 Serbia**

In Serbia, educators encounter significant challenges due to limited access to advanced UAV equipment, hindering effective training in UAV technology and coding. Technical issues such as memory constraints, power consumption, and the equipment's overall capabilities prevent instructors from conducting complex or realistic simulations. Moreover, there's a notable disconnect between theoretical knowledge and practical application, as students often miss out on hands-on experience with UAVs. This gap diminishes their ability to translate what they've learned theoretically into real-world coding scenarios, ultimately affecting their learning outcomes. To combat these challenges, Serbian educators have embraced simulation tools that replicate UAV operations and coding in virtual environments. These software programs offer a risk-free setting where students can practice coding and UAV handling without needing advanced physical gear. This innovative approach not only gives students valuable practical experience but also sharpens their problem-solving skills. Additionally, Serbian educators promote an interdisciplinary approach, allowing students to engage in projects that integrate various fields, including electronics, mechanics, and programming. This comprehensive learning strategy helps students appreciate the connections between disciplines, making their education in UAV technology and coding both relevant and expansive.

#### **4.2.5 Slovakia**

In Slovakia, the limited access to technology poses a significant challenge for implementing UAV and coding training. The lack of UAV equipment and coding tools hinders educators from providing students with crucial hands-on experience necessary for developing practical skills. Another pressing issue is the need for enhanced support to train educators. Many teachers require additional professional development to effectively teach these rapidly evolving subjects. To tackle these challenges, Slovakian educators have prioritized professional development. Ongoing training programs, workshops, and access to digital resources enable teachers to stay informed about the latest advancements in UAV technology and coding practices. Well-prepared instructors are essential for delivering effective lessons and meeting their students' learning needs. Moreover, Slovakia has embraced a collaborative learning approach to address resource limitations. Educators promote group projects and coding boot camps, fostering peer learning and allowing students to solve complex problems together. By encouraging teamwork and creating an environment that supports collaborative problem-solving, Slovakian educators strive to make the learning experience more engaging and accessible for all students.



## 4.2.6 Turkey

In Turkey, vocational training faces significant challenges due to limited resources and the high costs associated with UAV equipment and coding software. The expenses related to advanced technology often hinder educational institutions from giving students adequate access, restricting their practical learning experiences. Additionally, Turkish students have few opportunities for hands-on practice with UAVs and coding, making it difficult to apply their knowledge in real-world situations and truly grasp these skills. To address these issues, Turkish educators are seeking cost-effective solutions by sourcing locally produced UAV equipment and utilizing affordable resources to enhance student accessibility. By adopting practical alternatives, they can offer students a comparable learning experience without relying on expensive, imported materials. Another effective strategy is to integrate theoretical knowledge with practical application. Educators are leveraging open-source platforms and applied simulations to strengthen students' understanding of UAV coding. This approach allows students to hone their coding skills in a realistic yet controlled environment, bridging the gap between theory and practice. As a result, students build confidence and are better prepared for real-world applications.

## 4.3 Technical Barriers

In this section, we explore the technical barriers faced by each partner country and identify the specific challenges that must be addressed to achieve AVICO's educational objectives. As UAV technology and coding become increasingly essential across industries, integrating these skills into educational programs equips students for a variety of high-tech careers. However, each partner country experiences unique technical obstacles that hinder the effective teaching and learning of these skills. These challenges include limited equipment and resources, insufficient technical infrastructure, and high maintenance costs, all of which negatively affect students' ability to gain hands-on experience.

### 4.3.1 Croatia

In Croatia, one significant barrier to implementing UAV and coding education is the lack of advanced equipment for practical training. Educational institutions often struggle with the high costs of acquiring and maintaining UAVs and coding resources, making it difficult to integrate these technologies into their curricula. Moreover, the rapid evolution of technology means that much of the available equipment becomes outdated quickly, leading to a constant need for upgrades, which further strains financial resources. Educators also face challenges due to the limited availability of simulation software and other virtual training tools, which are essential for providing students with safe, risk-free learning experiences before they engage with actual UAVs.

### 4.3.2 Italy

In Italy, the integration of UAV technologies and coding into vocational education has faced significant technical barriers that hinder the effective delivery of these skills. One of the primary challenges is the limited availability of UAV equipment and resources in schools. Many institutions lack access to drones, simulation tools, and modern software, which are essential for providing hands-on training to students. This scarcity restricts the ability of educators to



deliver practical lessons that are critical for building technical proficiency.

Another obstacle is the insufficient technical infrastructure within many educational institutions. Issues such as outdated computer systems, inadequate internet connectivity, and the lack of dedicated spaces for UAV operations create logistical difficulties. These limitations not only reduce the scope of practical training but also undermine the integration of advanced technologies into existing curricula.

The high maintenance costs of UAV equipment also pose a significant challenge. Drones require regular maintenance, software updates, and repairs, which can strain institutional budgets, particularly in resource-constrained schools. This financial burden discourages the widespread adoption of UAV technologies in vocational programs and limits opportunities for students to gain hands-on experience.

Finally, educator preparedness remains a barrier. Many teachers have limited technical expertise in operating UAVs or integrating coding with drone applications. This skills gap further complicates the implementation of effective educational practices, as educators require substantial training and support to confidently deliver this content.

Addressing these technical barriers requires targeted strategies, including securing additional funding for equipment, improving institutional infrastructure, and offering professional development programs for educators. By overcoming these challenges, Italy can enhance its vocational education programs and better prepare students for careers in technology-driven industries.

### **4.3.3 Portugal**

In Portugal, limited access to UAV technology and software creates significant barriers for practical training opportunities. Many institutions struggle to offer students the hands-on experience necessary for mastering UAV mechanics and coding applications. The inadequate integration of advanced UAV software into educational curricula prevents students from developing essential skills, confining them to basic programming without delving into the more intricate aspects of UAV operation and autonomous flight. Moreover, maintaining UAV equipment can be resource-intensive; constant repairs and upkeep often prove unaffordable, compelling institutions to restrict usage to conserve resources. This mirrors challenges faced by educational institutions in Serbia, where access to high-quality UAV equipment is similarly constrained. Serbian schools grapple with UAVs that lack sufficient memory and processing power, limiting the complexities of coding and operational tasks available to students. They also face high operational costs associated with repairs, as UAVs are prone to wear and tear. The absence of simulation tools compounds these difficulties, leaving students with limited opportunities to practice and refine their skills in virtual environments, free from the risk of damaging physical equipment.

### **4.3.4 Slovakia**

Slovakia faces significant challenges due to limited access to UAVs and essential coding platforms. Many schools struggle to secure modern equipment, forcing students to use outdated technology that doesn't meet current industry standards. Compounding this issue, there's a shortage of specialized educators with the technical skills needed to maintain and



troubleshoot UAVs and their software. Furthermore, the lack of sufficient simulation tools restricts students from gaining practical experience in a safe and affordable environment. This gap hinders their ability to develop crucial UAV handling and coding skills essential for their future careers.

### **4.3.5 Turkey**

In Turkey, the funding challenges for UAV equipment and software create significant technical barriers. Many institutions lack the resources to purchase and maintain UAVs, which limits both the frequency and quality of practical training for students. Moreover, there is a notable shortage of technical expertise, as educators need further training to effectively teach UAV operations and coding, resulting in a critical gap in knowledge transfer. The absence of collaboration with the UAV industry hinders schools from accessing essential resources and training that could address these issues. Without strong industry partnerships, institutions struggle to maintain equipment and provide students with valuable hands-on learning experiences.

## **4.4 Student Engagement and Motivation**

Across the AVICO partner countries, educators face significant challenges in student engagement and motivation within UAV and coding programs. These issues arise from a blend of technical, conceptual, and resource-related factors. Through comprehensive surveys and interviews conducted in partner countries, the AVICO project has pinpointed specific challenges and innovative strategies that educators employ to enhance student engagement and sustain motivation in these courses. Below, we provide an overview of the engagement and motivational hurdles encountered in each country, along with effective strategies educators have implemented to overcome them.

### **4.4.1 Croatia**

In Croatia, one major challenge is keeping students motivated in subjects that often seem technical and abstract, especially when they have little prior experience with coding or UAV technology. This unfamiliarity can make these concepts feel overwhelming, leading to disengagement. Educators in Croatia have observed that the lack of practical learning tools, such as UAV simulation environments and opportunities for hands-on UAV handling, limits students' experiences and hinders long-term engagement. To tackle these issues, Croatian institutions are adopting project-based learning, where students engage in real-world tasks that involve coding and UAV applications. By presenting challenges in a practical, problem-solving context, educators aim to make the subject matter more relatable and engaging. Furthermore, many educators are utilizing simulation environments when possible, allowing students to explore UAV operations in a virtual setting. This provides a safe and cost-effective alternative to hands-on drone operation, fostering a more interactive learning experience.

### **4.4.2 Italy**

In Italy, educators face several challenges related to student engagement and motivation within UAV and coding programs. These challenges stem from a combination of technical barriers, limited resources, and the inherent complexity of the subjects. Students, especially



those with minimal foundational knowledge in coding or UAV operations, often struggle to connect with the material. This disconnect can lead to disengagement, particularly when theoretical concepts are not immediately tied to practical applications. Additionally, many students perceive coding and UAV technologies as intimidating or overly complex, which can discourage active participation and sustain interest.

Educators in Italy have implemented a variety of strategies to address these issues and foster a more engaging learning environment. One of the most effective methods has been the adoption of project-based learning approaches. By integrating real-world applications into the curriculum, educators provide students with tangible and relatable tasks, such as programming drones to perform specific missions or solve practical problems. This hands-on approach helps students see the immediate impact of their efforts, increasing their enthusiasm and interest in the subject.

Another key strategy is the use of gamification in teaching. Coding challenges, competitions, and reward-based systems have been introduced to make learning more dynamic and enjoyable. These elements encourage students to actively participate in lessons while fostering a sense of accomplishment and competition. Educators have also focused on creating collaborative learning environments where students work in teams on projects. This approach not only improves engagement but also enhances interpersonal and teamwork skills, making the learning process more interactive and supportive.

To address the initial intimidation many students feel, educators in Italy have adopted step-by-step learning pathways. These pathways begin with block-based programming tools, which are simpler and more intuitive for beginners, before progressing to more complex coding languages and UAV applications. This gradual progression helps students build confidence and develop a strong foundation for advanced topics.

Finally, educators have emphasized the importance of real-world career relevance to motivate students. By showcasing the growing demand for UAV and coding skills in industries such as agriculture, construction, and media production, they help students understand the long-term benefits of mastering these technologies. Guest lectures, industry collaborations, and practical demonstrations further bridge the gap between education and professional opportunities.

### **4.4.3 Portugal**

In Portugal, students favor hands-on, interactive learning but often find coding and UAV technologies daunting. The complexity of these subjects can make it challenging for students to grasp abstract concepts, leading to frustration and diminished motivation. Many feel that traditional methods like lectures and written notes fall short, especially when compared to engaging practical exercises and visual aids. To address these challenges, Portuguese educators have embraced various engagement strategies that emphasize interactive learning. Techniques like gamification and project-based assignments are being utilized effectively. For instance, incorporating leaderboards and small rewards for completing coding challenges turns coursework into a competitive and enjoyable game. Additionally, educators are integrating multimedia resources, including video tutorials and interactive applications, into the curriculum. This approach caters to various learning preferences, especially for students who benefit from visual and self-paced learning, making the educational experience more engaging and manageable.



#### **4.4.4 Serbia**

In Serbia, students often face challenges in staying engaged due to a lack of practical application for their theoretical knowledge. Many struggle with motivation in coding and UAV training because they don't have enough opportunities to use these skills in real-life scenarios. Additionally, the high technical demands can leave students feeling unprepared, leading to frustration and disconnection from their studies. To address these issues, Serbian educators stress the significance of hands-on learning through group projects and practical assignments. These collaborative tasks not only foster teamwork but also help students build confidence as they support one another. Furthermore, educators are adopting interdisciplinary methods that merge disciplines like electronics, mechanics, and aerodynamics with coding and UAV operations. This integration showcases the broader relevance of their technical skills and illustrates how UAV technology is applied in various fields, making the learning experience more meaningful and engaging.

#### **4.4.5 Slovakia**

In Slovakia, student motivation in UAV and coding education faces a significant hurdle: limited access to engaging resources and tools. This restriction hampers students' ability to connect theoretical concepts with practical applications. Many Slovakian students find traditional classroom settings uninspiring for these technical subjects, as they seek more interactive and hands-on learning experiences. To address this challenge, Slovakian educators are adopting gamification and blended learning models, which mix traditional teaching methods with digital tools. For example, coding exercises that provide real-time feedback and progressive skill challenges help students observe their immediate progress, fostering a sense of achievement. Additionally, institutions are creating collaborative learning environments through group projects and coding bootcamps. These setups allow students to practice UAV operations and coding in a dynamic, social context. This not only boosts engagement but also cultivates a supportive community of learners.

#### **4.4.6 Turkey**

In Turkey, students often struggle to stay motivated due to limited resources and the expensive nature of UAV equipment. This lack of access inhibits their practical application opportunities. While there is a strong interest in real-world uses of UAV technology and coding, many students feel discouraged by the scarcity of hands-on experiences. Moreover, the complex concepts involved in coding and UAV operation can be daunting, particularly for beginners. To address these challenges, Turkish educators have implemented innovative strategies to make learning more engaging. Collaborations with local technology companies allow students to access industry resources and expertise. Bringing in guest speakers and organizing field trips to UAV facilities help ground the curriculum in real-world context, enhancing its relevance. For increased accessibility, educators utilize open-source platforms for coding practice and simulations, providing students with cost-effective hands-on learning options. These initiatives aim to reignite motivation by allowing students to connect their skills to practical applications.



## 4.5 Effective Teaching Methods

Each participating country has described its own effective teaching methods, they are different and targeted to the Country context but all of them are aimed at boosting student engagement, fostering practical skills, and ensuring safe handling of advanced technology. These methods adapt to local resources, student needs, and institutional goals, incorporating strategies such as project-based learning and simulations. Below is an overview of the teaching methods adopted by each country in the AVICO project.

### 4.5.1 Croatia

In Croatia, educators have discovered that project-based learning is highly effective for teaching UAV and coding skills. By focusing the curriculum on real-world projects, students can apply theoretical knowledge in practical settings, which boosts their comprehension and retention of complex concepts. This approach not only reinforces technical skills but also enhances critical thinking and problem-solving abilities. Croatian educators further enrich the learning experience by incorporating physics and engineering into UAV training. This multidisciplinary strategy expands students' perspectives and illustrates the wide-ranging applications of UAV technology across various sectors.

### 4.5.2 Italy

In Italy, the teaching methods adopted for UAV and coding education are designed to align with the country's educational context while fostering student engagement, practical skills, and technological proficiency. These methods leverage a combination of hands-on training, theoretical instruction, and innovative approaches to ensure students are well-prepared for the demands of the modern workforce. One of the most prominent methods used in Italy is project-based learning, which integrates real-world applications into the curriculum. By engaging students in tasks like programming drones for specific missions or solving practical challenges, educators create a dynamic and interactive learning environment. This approach not only makes lessons more engaging but also helps students develop critical thinking and problem-solving skills by applying theoretical knowledge to tangible projects.

Simulations and virtual environments are another critical component of teaching methods in Italy. These tools allow students to practice drone operations and programming in a controlled, cost-effective, and safe manner before transitioning to real UAVs. Simulations reduce the risk of accidents and equipment damage while providing a comprehensive understanding of UAV technologies.

Educators also emphasize the importance of collaborative learning by encouraging teamwork and group projects. This method helps students build interpersonal skills while tackling coding and UAV-related challenges together, fostering a supportive learning environment. Collaborative tasks often mimic real-world scenarios, preparing students for professional team dynamics in the workplace.

A progressive curriculum structure is employed to ensure students can gradually build their knowledge and skills. This starts with simple, block-based programming tools, such as Scratch,



which are more accessible for beginners, and progresses to text-based programming languages like Python or C++ for more advanced applications. This step-by-step approach ensures students gain confidence as they move from foundational concepts to complex UAV operations and coding tasks.

To enhance engagement and motivation, gamification techniques are incorporated into the teaching process. These include coding competitions, interactive challenges, and reward-based activities, which make learning enjoyable and encourage active participation. Gamification transforms potentially intimidating subjects like programming and UAV operations into approachable and stimulating experiences.

Finally, the integration of industry collaboration plays a significant role in effective teaching methods in Italy. Schools work with local businesses and technology firms to provide students with real-world exposure, mentorship opportunities, and access to cutting-edge tools and applications. Guest lectures and site visits help students understand the practical applications of their skills, bridging the gap between education and professional practice.

### **4.5.3 Portugal**

In Portugal, students thrive on practical, hands-on learning. The AVICO project taps into this preference by integrating real-life projects and video lessons into the curriculum. These real-life projects are especially popular, enabling students to confront real-world challenges while honing skills relevant to industry settings. Additionally, video lessons and multimedia content cater to visual learners and enrich the educational experience. Portuguese educators also utilize simulation applications for UAV training. This approach allows students to practice coding and navigation tasks in a controlled setting, eliminating the risks of operating physical UAVs. Such strategies not only engage students actively but also deepen their understanding of UAV technology and coding.

### **4.5.4 Serbia**

In Serbia, effective teaching methods similarly emphasize simulation tools and collaborative projects. Simulations enable students to safely explore UAV coding and operations, allowing for scenario testing without the need for expensive equipment. Group projects foster teamwork and collaborative learning, encouraging students to develop communication skills and offering peer support that boosts motivation. Moreover, educators in Serbia support a flexible curriculum that accommodates diverse skill levels, encouraging the inclusion of personal projects. This flexibility promotes a sense of ownership in the learning process, making education more impactful for students.

### **4.5.5 Slovakia**

In Slovakia, a hybrid learning model has proven highly effective. By blending traditional classroom instruction with online resources, students can learn at their own pace and explore a broader range of educational materials. This approach is especially valuable for complex subjects like UAV coding, where additional time is often necessary to master challenging concepts. Educators enhance engagement and motivation through gamification techniques, such as coding challenges and rewards. Furthermore, collaborative learning environments, including coding bootcamps and group tasks, enable students to work together, share



knowledge, and tackle intricate projects in a social, interactive setting. This synergy not only enriches the learning experience but also cultivates essential teamwork skills.

#### **4.5.6 Turkey**

In Turkey, educators are adopting innovative teaching methods and interdisciplinary approaches to enhance students' skills in UAV technology and coding. By introducing a range of programming languages like Python and Java, they prepare students to engage with various technologies effectively. The focus on practical applications and simulations allows learners to apply theoretical knowledge in real-world scenarios. Moreover, Turkish educators emphasize the importance of accessible educational materials, aimed at leveling the playing field to ensure that every student has the opportunity to succeed. Structured programs centering on algorithms and problem-solving skills are being developed, featuring both visual and verbal explanations to meet diverse learning needs. This holistic approach fosters an inclusive and engaging learning environment for all students.

## **5 Competency Framework**

A competency framework is a structured outline that defines the essential skills, knowledge, and behaviors needed to excel in a specific field. It charts a clear path for skill development, from foundational abilities to advanced expertise, enabling both learners and educators to track progress effectively. By specifying competencies, the framework ensures that training is comprehensive, standardized, and aligned with real-world demands, particularly in fast-evolving sectors like UAV technology and coding.

In the realm of Drone Coding Skills and Training, this competency framework encompasses technical, analytical, and interpersonal skills vital for safe and effective UAV operation, programming, and application. It serves as a roadmap for curriculum design, learning evaluation, and fostering progressive mastery. With a clearly defined set of competencies, students can establish a solid foundation and continue to enhance their expertise as they tackle more complex applications.

### **5.1 Competency Descriptions**

The Figure 1 and Table 1 list the broader competencies for effective UAV operation and coding. They are organised into categories, which cover technical skills in UAV mechanics and programming, analytical abilities for data processing and problem-solving, and interpersonal skills vital for teamwork and adaptability. These competencies equip learners to tackle diverse challenges in UAV technology, ranging from basic flight control and coding to advanced skills in autonomous navigation, data integration, and regulatory compliance. This framework sets the foundation for a comprehensive learning experience, preparing students for the current and future demands of the UAV and coding fields.



Figure 1 AVICO broader competences for effective UAV operation and coding

Table 1 AVICO broader competences for effective UAV operation and coding

AREA	COMPETENCY
<b>Technical Competencies</b>	
<b>UAV Operations and Safety</b>	Fundamentals of UAV Mechanics: Understanding parts and mechanics of UAVs, including rotors, sensors, GPS, etc.
	Flight Control and Stability: Skills for basic manual control, takeoff, landing, and maintaining stable flight.
	Safety Protocols and Compliance: Knowledge of safety checks, emergency procedures, and regulatory compliance.
<b>Coding and Programming for UAV Applications</b>	Introduction to Coding Languages: Basic proficiency in languages like Python or C++ for UAV operations.
	Basic UAV Coding Functions: Writing simple code for UAV navigation, speed, and orientation control.
	Troubleshooting and Debugging: Identifying and correcting coding errors that affect UAV performance.

AREA	COMPETENCY
<b>Advanced Systems Integration and Autonomous Programming</b>	Sensor and Data Integration: Programming for real-time data capture and integration from UAV sensors.
	Autonomous UAV Flight: Advanced coding for autonomous navigation, route planning, and obstacle avoidance.
	API Usage and Software Libraries: Proficiency in using APIs and libraries for efficient UAV operations.
<b>Analytical and Problem-Solving Competencies</b>	
<b>Data Collection and Analysis</b>	Data Acquisition: Capturing relevant data from UAV sensors for applications like mapping or monitoring.
	Data Processing and Analysis: Skills in processing and analyzing UAV data, using basic tools and methods.
	Application of Analytical Tools: Using software for interpreting UAV data, including basic ML for data categorization.
<b>Project-Based Problem Solving and Real-World Application</b>	Coding in Context: Applying coding in real-world UAV projects, such as environmental monitoring or land surveying.
	Iterative Problem-Solving: Skills in iterative testing, debugging, and optimization of UAV coding tasks.
	Adaptation and Optimization: Adapting code for efficiency and optimizing UAV performance in various scenarios.
<b>Interpersonal and Soft Skills</b>	
<b>Team Collaboration and Communication</b>	Collaboration in Multidisciplinary Teams: Effective teamwork across diverse technical backgrounds.
	Technical Communication: Ability to communicate coding and UAV technical concepts to varied audiences.
<b>Adaptability and Lifelong Learning</b>	Continuous Learning in Technology: Staying updated with new UAV and coding technologies.
	Resilience in Problem-Solving: Perseverance in troubleshooting and applying lessons learned to new challenges.
<b>Project Management and Critical Thinking</b>	Project Planning and Execution: Skills in planning, setting goals, and managing resources in UAV projects.
	Analytical and Critical Evaluation: Evaluating UAV applications critically, identifying areas for improvement.

AREA	COMPETENCY
<b>Advanced Industry-Specific Competencies</b>	
<b>Integration of AI and Machine Learning (ML) with UAVs</b>	Foundational AI and ML Knowledge: Understanding AI/ML principles such as pattern recognition for UAV tasks.
	Machine Learning Model Application: Coding for UAV functions using ML, like navigation or object detection.
<b>Ethical and Regulatory Competencies</b>	Ethics in UAV and Data Usage: Awareness of privacy, data security, and responsible UAV operation.
	Regulatory Compliance and Adaptation: Familiarity with UAV regulations and the ability to adjust practices for compliance.

## 5.2 Core Competencies for Coding and UAV Skills

Core competencies (Table 1) are the essential skills and foundational knowledge that equip learners with the baseline proficiency needed for successful UAV operation and coding (Figure 2). Unlike broader competencies that encompass advanced skills, core competencies home in on the fundamental areas crucial for beginners.

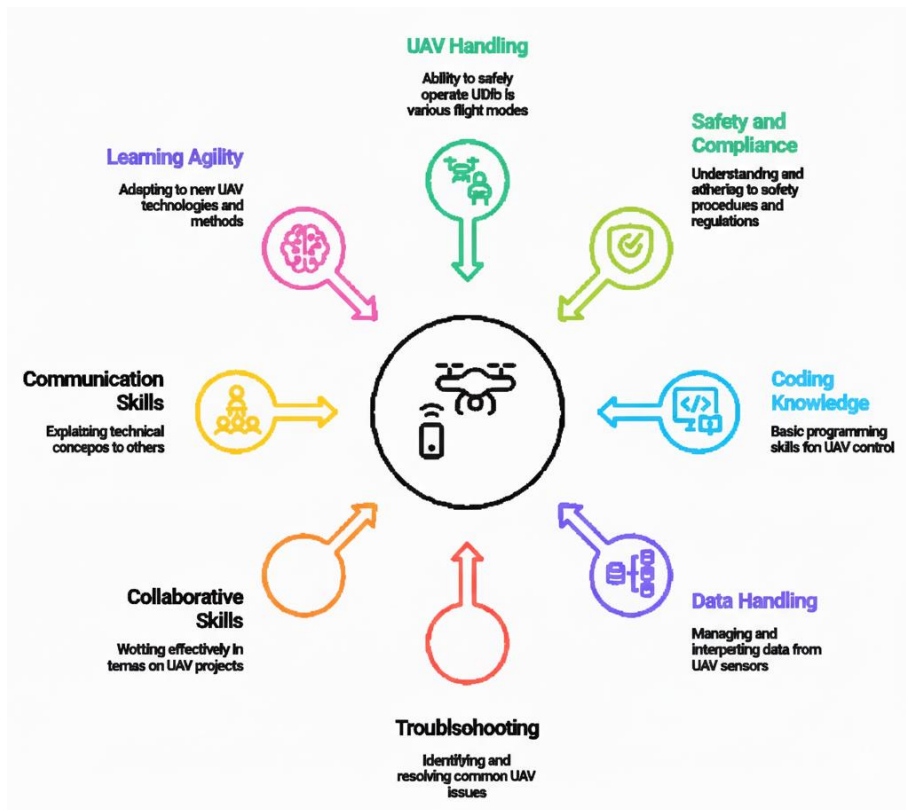


Figure 2 AVICO Core Competencies for Coding and UAV Skills

Focusing on these key skills enables students to safely operate drones, write basic control code, and think critically in practical situations. By building a solid foundation, learners gain



the confidence and adaptability needed to take on more complex challenges as their training progresses. This targeted approach transforms core competencies into vital building blocks, ensuring students transition smoothly from foundational tasks to specialized UAV applications and coding. Ultimately, this preparation sets them up for success in the fast-growing field of UAV technology.

Table 2 AVICO Core Competencies for Coding and UAV Skills

Core Competency	Description
<b>Basic UAV Handling</b>	Demonstrate the ability to operate UAVs safely, including takeoff, landing, and maintaining stable flight.
<b>Safety and Compliance Basics</b>	Understand fundamental safety procedures and essential regulatory requirements for UAV operation.
<b>Introductory Coding Knowledge</b>	Understand programming, focusing on a relevant language like Python for UAV controls.
<b>Simple Coding for UAV Movement</b>	Write basic code to direct UAV movement, enabling navigation, hovering, and other simple operations.
<b>Data Handling</b>	Collect, store, and manage data from UAV sensors for basic analysis and interpretation.
<b>Troubleshooting Essentials Identifies</b>	Identify and resolve common issues in UAV coding or operation, utilizing basic problem-solving skills.
<b>Collaborative Skills Works</b>	Work effectively within a team on UAV and coding projects, contributing to group tasks and outcomes.
<b>Basic Communication of Technical Concepts</b>	Explain fundamental UAV operations and coding tasks to others, including non-technical peers.
<b>Learning Agility</b>	Demonstrate openness to learning new UAV and coding technologies, adapting flexibly to evolving tools and methods.

## 5.3 Recommendations

Based on the identified key findings for teaching UAV and coding skills, there are several detailed recommendations to enhance the effectiveness of the AVICO project. These recommendations aim to address the core areas of technical barriers, student engagement, teaching methods, resource limitations, and continuous learning and development to create a well-rounded educational experience for students. They are also tailored to ensure that the established competencies are implemented effectively in both curriculum development and classroom practice, providing students with a strong, industry-aligned skill set.

To address **technical barriers**, it's crucial to enhance access to updated UAV equipment, coding software, and simulation tools. Many institutions struggle with limited resources,



hindering students' chances for hands-on learning with modern technologies. Securing additional funding can empower schools to invest in these essential tools, effectively bridging the gap between theory and practice. Simulation tools stand out as a cost-effective alternative to expensive UAV hardware, offering safe and repeatable environments where students can refine their UAV operation and coding skills. Forming partnerships with industry leaders can also help mitigate these technical challenges. Collaborating with UAV and technology companies may provide access to discounted or even donated equipment, along with much-needed technical support to help educators maintain and troubleshoot their tools. These partnerships can also create mentorship opportunities, enriching the learning experience for both students and teachers. Furthermore, continuous training for educators is vital. Well-prepared instructors, equipped with current technical skills, are essential for effectively teaching the complexities of UAV technology and coding.

Enhancing **student engagement and motivation** is a top priority. Project-based learning stands out as an effective approach, allowing students to apply theoretical concepts in real-world contexts. This method deepens understanding and makes learning more relevant and meaningful. When students work on practical projects, they witness the real-world impact of their skills, significantly boosting engagement. Incorporating gamification and coding challenges into the curriculum further elevates motivation. These strategies introduce a competitive yet enjoyable element to learning, enabling students to earn rewards and track their progress through leaderboards. Such interactive techniques create a dynamic and enjoyable learning experience, encouraging consistent engagement with the material. To maintain motivation, it's essential to highlight career pathways linked to UAV and coding skills. By showcasing how these skills connect to high-demand job markets, students can better appreciate the long-term benefits of their education. Schools can enhance this connection by inviting industry professionals as guest speakers or organizing visits to companies that utilize UAV technology, effectively illustrating potential career opportunities. Interdisciplinary learning also broadens student engagement by demonstrating how UAV technology and coding intersect with fields like physics, engineering, and environmental science. This approach shows students the versatility of their skills, fostering a sustained interest in learning.

**Effective teaching methods** are crucial to the success of the AVICO project. Blended learning models, which integrate traditional classroom instruction with online resources, are particularly advantageous for complex subjects like UAV coding. This approach allows students to learn at their own pace, access diverse materials, and revisit challenging concepts as needed. Blended learning provides the flexibility necessary for students to engage with difficult material on their own terms, significantly enhancing their comprehension. Additionally, expanding hands-on practical experiences is vital for reinforcing learning. Activities such as simulations, project-based tasks, and real-world UAV handling help solidify theoretical knowledge and boost students' confidence in their skills. Collaborative learning environments further enhance effectiveness. Group projects and coding boot camps enable students to work together, share insights, and tackle complex tasks as a team. This collaboration not only sharpens technical abilities but also fosters essential soft skills like communication and teamwork, which are invaluable in any career. Incorporating visual and interactive content, such as video tutorials and multimedia applications, enhances engagement by addressing different learning preferences. This variety makes it easier for students to grasp complex concepts through multiple instructional formats.



To tackle **resource constraints** effectively, it's crucial to develop cost-effective learning resources. Utilizing open-source platforms and affordable coding tools enhances accessibility for all students, minimizing reliance on expensive equipment while delivering a rich learning experience. In areas with high costs, considering locally produced UAV equipment or alternatives can achieve similar educational benefits at a lower price point. This strategy empowers institutions to offer hands-on experiences without the heavy costs associated with imported technology. Creating a resource-sharing network among AVICO partner countries can further enhance resource efficiency. By collaborating on lesson plans, software licenses, and equipment, partner institutions can alleviate the overall resource burden. This ensures that more students have access to valuable educational materials without incurring duplicated costs across institutions.

Supporting **continuous learning and development** is essential in the dynamic fields of UAV and coding education. By offering flexible learning pathways, we cater to students of all skill levels, allowing them to progress at their own pace. This approach benefits those who need extra time to grasp concepts without falling behind, while more advanced students can delve into complex material sooner. Regular curriculum updates are crucial for maintaining relevance with industry standards and technological advancements. By routinely incorporating feedback from industry experts, we ensure our educational content aligns with real-world applications, equipping students with in-demand skills. Moreover, emphasizing soft skills like teamwork, communication, and problem-solving prepares students for both technical roles and collaborative work environments. Integrating these skills into the curriculum enhances technical abilities and fosters well-rounded professionals ready to make a significant impact in their fields.

With a **comprehensive framework of competencies** in place, it's vital to ensure that each competency area and its descriptions meet the practical needs of UAV and coding education. The framework categorizes competencies into technical, analytical, and soft skills, encompassing foundational knowledge in UAV operations, coding abilities, and problem-solving skills. To effectively integrate this framework into educational environments, each AVICO partner institution should align its curriculum with these defined areas and competencies. This alignment will foster consistency across educational settings, providing students with clear goals and measurable outcomes. To enhance the framework's effectiveness, it is recommended to establish learning stages within each competency area, progressing from beginner to advanced levels. For example, basic UAV handling and coding skills should be introduced early in the curriculum, allowing students to build confidence before tackling more complex tasks like autonomous programming and sensor integration. Regular assessments at each stage will enable educators to track student progress and readiness for advancement, ensuring alignment with the detailed descriptions in the competency framework.

# PART B

## 1 Didactic Framework

Coding, as a complementary skill, empowers students to program and operate UAVs effectively, preparing them for careers in emerging industries such as agriculture, logistics, media, and public safety. This section outlines the Didactic Principles and Educational Approaches that underpin the AVICO project’s teaching methodology (Figure 3). These principles emphasize student-centered and experiential learning, while the approaches integrate hands-on projects, simulations, and competency-based frameworks. Together, they aim to create engaging, inclusive, and industry-relevant educational experiences, ensuring that students acquire both technical expertise and the broader competencies necessary for success in a technology-driven world.

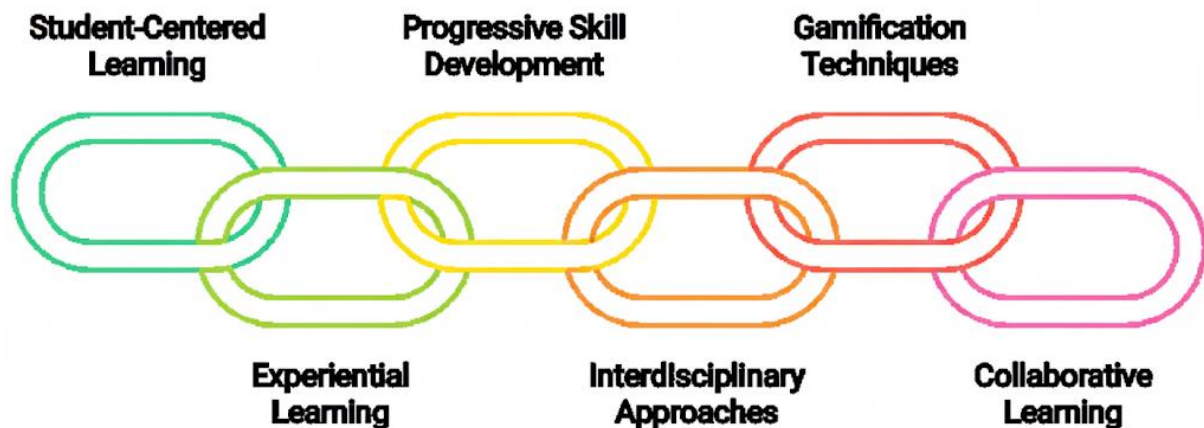


Figure 3 AVICO educational framework

### 1.1 Didactic Principles

A key principle is **student-centered learning** (Figure 4), where the instructional process is tailored to the needs and capabilities of individual learners. This approach encourages active participation, allowing students to explore UAV and coding concepts through self-directed learning activities that cater to their interests and levels of expertise.

**Experiential learning** is another cornerstone of the educational framework. By incorporating hands-on activities, such as programming drones to perform specific tasks or conducting real-world UAV missions, students can directly apply theoretical knowledge to practical scenarios. This method bridges the gap between classroom learning and real-world applications, reinforcing understanding through active engagement.

The project emphasizes **progressive skill development**, ensuring that students acquire foundational skills before moving on to more advanced competencies. This involves starting with simple, block-based programming tools and basic UAV operations, which gradually lead to more complex text-based coding languages and autonomous UAV programming. This structured progression builds confidence and competence in learners.



**Interdisciplinary approaches** are integrated into the learning process, connecting coding and UAV technologies with subjects such as physics, engineering, and environmental science. By highlighting these cross-disciplinary applications, students gain a broader perspective on the practical relevance of their skills across various domains.

To enhance motivation and engagement, **gamification techniques** are incorporated into the teaching strategy. Coding challenges, friendly competitions, and reward systems transform technical subjects into enjoyable experiences, making learning more interactive and stimulating.

Finally, the principle of **collaborative learning** is central to the AVICO approach. Students are encouraged to work in teams on group projects and problem-solving tasks. This not only fosters interpersonal and communication skills but also replicates the dynamics of real-world professional environments, preparing students for collaborative workplaces.

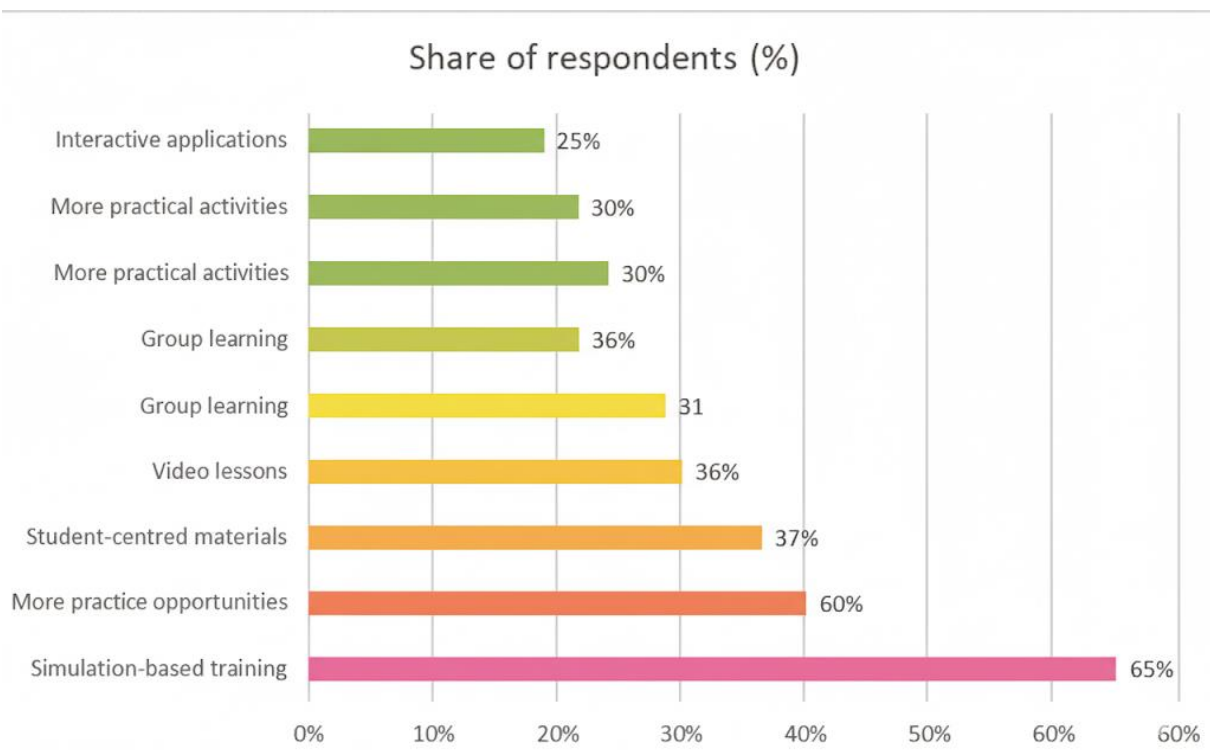


Figure 4 AVICO survey findings supporting didactic design (Source: AVICO Transnational Report (student survey findings))

## 2 Educational Approaches

The AVICO project employs a multifaceted educational approach to effectively integrate UAV technologies and coding education into vocational training. This approach prioritizes adaptability, engagement, and the alignment of educational methods with industry needs to ensure students acquire the technical and professional skills necessary for success in the modern workforce. A key component of this approach is **blended learning**, which combines traditional classroom instruction with online resources, such as simulations, tutorials, and digital tools. This method caters to diverse learning preferences and allows students to progress at their own pace, ensuring that both foundational concepts and advanced skills are effectively addressed. The inclusion of digital tools and virtual environments enhances



accessibility while providing students with a modern and interactive educational experience.

**Project-based learning** is another cornerstone of this methodology. By engaging students in hands-on projects that simulate real-world applications, such as programming UAVs for specific tasks or analyzing data collected through drones, students develop critical thinking and problem-solving skills. These projects not only reinforce theoretical knowledge but also provide practical experience, enabling learners to see the tangible impact of their efforts.

To ensure a safe and cost-effective learning environment, **simulation-based training** plays a crucial role. Virtual environments are utilized to mimic UAV operations and coding exercises, allowing students to gain practical experience without the risks or costs associated with physical equipment. Simulations provide a controlled setting where learners can experiment, make mistakes, and refine their skills before transitioning to real-world applications.

The curriculum is designed with a **competency-based learning** framework, ensuring that instruction and assessments are aligned with clearly defined outcomes. Students are guided to achieve measurable competencies in UAV operations and coding, with an emphasis on building a solid foundation before progressing to more complex tasks. This structured approach ensures that every learner masters the essential skills needed for their professional development.

Regular **feedback and assessment** are integral to this approach, providing continuous opportunities to evaluate student progress and address learning gaps. Educators implement frequent assessments and maintain open feedback loops to help students stay on track and make informed improvements in their learning journey.

A significant emphasis is placed on **employability**, with the curriculum integrating industry-relevant skills and offering students exposure to professional practices. Collaborations with businesses, guest lectures from industry experts, and real-world projects help bridge the gap between education and the workplace. This ensures that students graduate with not only technical expertise but also a clear understanding of the expectations and opportunities in their chosen industries.

## 2.1 Teaching and Learning Methods

The AVICO project employs a possible range of teaching and learning methods to effectively integrate UAV technologies and coding into vocational education. These methods are designed to enhance student engagement, develop technical and professional skills, and prepare learners for real-world applications in industries such as agriculture, logistics, and public safety.

1. **Blended Learning** combines traditional classroom instruction with digital resources, such as tutorials, simulations, and online platforms. By leveraging a mix of face-to-face and virtual learning experiences, students can explore UAV operations and coding concepts at their own pace while benefiting from the guidance of educators during classroom sessions. This approach ensures flexibility and accommodates diverse learning preferences.
2. **Project-Based Learning** engages students in hands-on projects that simulate real-world challenges, such as programming drones to perform specific tasks or analyzing drone-captured data. This approach encourages critical thinking, creativity, and



problem-solving, as students apply theoretical knowledge to practical scenarios. Projects are often interdisciplinary, integrating coding with other subjects like physics, engineering, and environmental science.

3. **Simulation-Based Training** provides a safe and controlled learning environment, virtual simulations are used to teach UAV operations and coding exercises. Simulations enable students to practice tasks such as autonomous navigation, obstacle avoidance, and mission planning without the risks associated with real drones. This method is particularly effective in resource-constrained settings or during the initial stages of skill development.
4. **Collaborative Learning** helps students develop interpersonal skills, enhances peer-to-peer learning, and mirrors real-world workplace dynamics. By working together on shared tasks, students learn to manage roles, communicate effectively, and integrate diverse perspectives into their work.
5. **Competency-Based Learning** involves clear learning outcomes for each stage of UAV and coding education, starting with foundational concepts and progressing to advanced applications. Competency-based learning ensures that every student achieves the necessary standards of technical proficiency and understanding.
6. **Continuous Feedback and Assessment** to track student progress and address learning gaps. Educators employ formative assessments, such as quizzes and practical demonstrations, alongside summative evaluations to ensure a comprehensive understanding of student performance. Feedback is tailored to guide students in refining their skills and achieving their learning goals.
7. **Gamification** such as coding competitions, challenges, and reward systems, enhances student engagement and motivation. This method transforms technical learning into an interactive and enjoyable experience, encouraging students to actively participate and strive for excellence.
8. **Industry Collaboration** is provided through partnerships with industry professionals. Guest lectures, internships, and collaborative projects with companies help students understand the practical applications of UAV technologies and coding in professional contexts. These experiences bridge the gap between classroom learning and industry requirements, ensuring students are workforce-ready.

## 3 Key Indicators for Learning and Skill Development

To ensure that UAV and coding education is effective, measurable and relevant to vocational training, AVICO proposes a set of key indicators that allow educators to monitor both the **learning process** and the **development of competencies over time**. These indicators are not limited to technical performance. They also reflect engagement, progression, confidence, collaboration and the ability to apply knowledge in practical contexts. This broader view is important because UAV and coding education requires the integration of digital, operational and transversal skills rather than isolated subject knowledge alone.



The key indicators should help educators answer three practical questions: Are students actively engaging with the learning process? Are they progressing from basic to more advanced competencies? And are they becoming able to use coding and UAV technologies in realistic vocational scenarios? In AVICO, this logic is closely connected to the competency framework, which supports gradual development from beginner-level understanding to more complex skills such as autonomous programming, system integration and data-based task execution.

Because the project research showed strong interest in simulation-based learning, practical activities, video-based support and student-centred materials, the indicators should also capture the extent to which the learning environment responds to these preferences. In this sense, indicators in AVICO are not only assessment tools; they are also quality tools that help institutions evaluate whether the didactic model is aligned with student needs and labour-market expectations.

### 3.1 Performance Indicators

Performance indicators describe how students **participate, practise and progress during the learning process**. They focus on observable behaviours and interim achievements that show whether teaching methods are working effectively and whether learners are building confidence step by step. In UAV and coding education, such indicators are especially important because students often begin with very different entry levels, and progress is best captured through continuous observation rather than only final testing.

Relevant AVICO performance indicators may include:

- active participation in coding exercises, simulations and practical UAV tasks;
- ability to follow instructions and complete guided tasks safely and correctly;
- progression from block-based or introductory coding to more complex coding logic;
- ability to apply coding concepts to mission planning, automation or sensor-based tasks;
- quality of teamwork, communication and role-sharing in collaborative projects;
- ability to solve problems, debug errors and adapt to new tools or technical challenges;
- responsible behaviour in relation to safety, equipment handling and compliance.

These indicators can be monitored through observation sheets, practical demonstrations, short quizzes, simulation logs, peer feedback and teacher notes. The goal is to give educators clear evidence of student development before moving to more advanced tasks.

### 3.2 Outcome Metrics

Outcome metrics measure the **results and longer-term value** of the training. While performance indicators focus on the learning journey, outcome metrics focus on whether students reach the intended level of competence and whether the training contributes to employability, further learning and real-world application. This distinction is important in AVICO, where the objective is not only to introduce students to UAV technologies, but to prepare them for meaningful use of these technologies in sectors such as agriculture, logistics,



environmental monitoring and public safety.

Possible AVICO outcome metrics include:

- achievement of defined competencies in UAV operation and coding;
- successful completion of project tasks or real-world scenarios;
- ability to independently plan, execute and evaluate UAV-supported assignments;
- increased digital confidence and readiness to work with emerging technologies;
- improved alignment between training outcomes and labour-market needs;
- participation in internships, projects, further study or employment pathways linked to digital or UAV-related sectors;
- educator feedback on the relevance and transferability of acquired skills.

Outcome metrics may be collected through final practical assessment, portfolio review, project presentations, self-reflection, stakeholder feedback and follow-up data from institutions or training providers.

### 3.3 Didactic Support for Educators

The AVICO research clearly shows that educator preparedness is one of the main conditions for successful implementation. Teachers need not only content knowledge, but also practical tools that reduce uncertainty and help them organise learning in a structured, safe and motivating way. For this reason, the VET Guide should function as a source of **didactic support**, not only as a conceptual document.

Didactic support for educators in AVICO should include pre-structured lesson plans, sample project tasks, assessment rubrics, safety and compliance tools, reflection instruments, and recommendations for simulations, tutorials and software. These resources can support both experienced teachers and those who are only beginning to work with UAV and coding education. Their purpose is to make the teaching process more consistent, reduce preparation time, and help educators translate the AVICO competency framework into real classroom practice.

The most valuable forms of support are those that connect pedagogy with feasibility: practical guidance for step-by-step progression, adaptable examples for different levels of infrastructure, and clear support for blending theory, simulation and hands-on work. This is particularly important in contexts where schools face limited equipment access or where teachers need stronger confidence in safety procedures and technical delivery.

### 3.4 Learning Environment and Classroom Management

An effective learning environment for UAV and coding education must combine **technical structure, safety, flexibility and collaboration**. AVICO findings indicate that students benefit most when they can move between different forms of learning: explanation, coding practice, simulation, guided experimentation and, where possible, supervised real UAV activity. This means the classroom should not be seen as a traditional lecture space only, but as a flexible learning environment that supports both digital and physical interaction.



Good classroom management in this field begins with clear organisation. Students should understand roles, timing, safety rules, task sequences and expected outcomes before practical activities begin. In collaborative lessons, it is useful to assign rotating roles such as pilot, programmer, observer, recorder or safety checker, so that each learner engages with more than one dimension of the task. This supports both technical development and teamwork.

Safety management is essential. Teachers should establish pre-flight routines, equipment checks, restricted movement zones, emergency procedures and clear behavioural expectations for indoor or outdoor practice. Where direct flight is not possible, simulation-based training offers a safe and cost-effective alternative that still supports authentic skill development. AVICO findings and literature both confirm that simulation is especially valuable in resource-constrained settings and in the early stages of learning.

Finally, classroom management should also support inclusion and progression. Students may differ significantly in digital confidence and prior exposure to coding. For this reason, tasks should be scaffolded, support materials should be available in multiple formats, and educators should create an atmosphere where experimentation, mistakes and feedback are treated as normal parts of the learning process.

## 4 Templates for Didactic Resources

### 4.1 Lesson Plan Templates

Each lesson plan should include:

- lesson title,
- target group,
- duration,
- learning objectives,
- required equipment,
- safety notes,
- step-by-step activities,
- links to simulations or tutorials,
- assessment method and reflection questions.

The template should help teachers organise progression from theory to practice and ensure that each lesson is linked to specific competencies.

### 4.2 Assessment Rubrics

Assessment rubrics should evaluate both **technical** and **transversal** dimensions of learning. Recommended criteria include coding accuracy, completion of task logic, UAV handling or simulation performance, problem-solving, teamwork, communication, safety awareness and ability to explain decisions. Rubrics should use progressive levels such as beginner, developing, competent and advanced.



## 4.3 Safety and Compliance Checklists

Checklists should support responsible training before, during and after practical activities. They may include:

- battery and equipment check,
- software readiness,
- propeller and frame inspection,
- weather and space suitability,
- local regulatory compliance,
- role assignment,
- emergency-stop awareness,
- post-activity storage and reporting.

These checklists help embed safety culture into routine teaching.

## 4.4 Links to Recommended Tutorials, Software and Literature

The guide should include a curated resource section with recommended drone simulators, coding platforms, beginner tutorials for block-based and text-based programming, mission-planning software, open-source environments where possible, and reference links to the AVICO literature review. This gives educators a direct bridge from the guide to concrete implementation tools.

# 5 Conclusion

The Kit brings together the main outcomes of the first project phase and provides a structured foundation for integrating UAV technologies and coding education into vocational training. By combining evidence from the literature review, expert interviews, student surveys and national reports, the guide translates research findings into a practical and pedagogically relevant framework for educators, trainers and institutions. Its value lies not only in describing current needs and trends, but in offering a coherent basis for curriculum design, didactic planning and future-oriented skills development in vocational education.

The research carried out within AVICO confirmed that there is a strong and growing rationale for combining UAV operation with coding skills. UAV technologies are expanding across multiple sectors, while vocational education systems are still adapting to the pace of technological change. The findings showed a clear need for more flexible curricula, stronger practical orientation, better access to resources and equipment, and closer alignment between education and labour-market expectations. At the same time, students and experts highlighted the value of hands-on learning, simulation-based training, video-supported instruction, project work and stronger cooperation with industry. These insights shape the educational logic of the guide and reinforce the importance of a modern, applied and



competence-based approach.

One of the Kit's main contributions is that it transforms these findings into an actionable framework. Through its competency model, didactic principles, indicators for learning and development, and practical support tools for educators, the guide offers a roadmap for gradual and meaningful implementation. It supports progression from introductory UAV handling and basic coding to more advanced tasks such as automation, data use and problem-solving in authentic scenarios. In this way, the guide helps move VET provision from fragmented experimentation towards a more systematic and transferable model of UAV and coding education.

The Kit should also be understood as a living and developmental document. It is not the final endpoint of the project, but a core reference that will inform the next phases, including curriculum development, OER production, simulation-based experimentation and MOOC implementation. Its purpose is to ensure that these later outputs remain anchored in real educational needs, validated stakeholder insights and a shared pedagogical logic across the partnership. Because AVICO results are designed as open and reusable resources, the guide also contributes to wider sustainability, transferability and future use beyond the immediate project consortium.

Ultimately, AVICO responds to a wider challenge facing vocational education today: how to prepare learners for a labour market shaped by digitalisation, automation and interdisciplinary technologies. By linking UAVs with coding, the project supports not only technical upskilling, but also problem-solving, adaptability, collaboration and confidence in working with emerging technologies. The Kit therefore represents more than a methodological output. It is a strategic contribution to more innovative, inclusive and future-oriented vocational education, helping institutions create learning pathways that are relevant, engaging and aligned with the realities of a rapidly changing world.