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A Sustainable Framework for Providing Early Exposure to Aviation Education

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INTRODUCTION

Several factors have been attributed to the pilot workforce shortage, among them include the consistent growth of the air transport industry, expected pilots' retirements, and high training costs. In Ohio, it is projected that between 2020 and 2030, the working population age 65 and above, across all industries in Ohio, will continue to increase by 18.4% while the working population between 25 and 64 years of age will decrease by 5.5% [1]. This presents a challenge for aircraft pilot demand since as the air transportation is expected to grow, the employment for both airline and commercial pilots in Ohio is expected to increase by 4.9% and 4.5% respectively between 2020 and 2030 [1]. The International Air Travel Association (IATA) has estimated that the number of commercial aviation passengers would grow by an additional 4.3 billion passengers between 2023 and 2043 [2], [3]. This would eventually require about 50,000 airplanes worldwide [4], [5] and, hence, a about 674,000 new pilots between the same period to be trained [6]. Undiversified pilot corps is also another challenge as currently less than one in six pilots are either women or other minority personnel [7].

This work therefore proposes an educational framework to help faculty in creating and delivering a sustainable aviation curriculum to be taught to high school students. Specifically, the framework is designed to deliver a meaningful education to high school teachers, who in turn will teach high school students, with the goal of attracting them to become aircraft and UAS operators. The sustainability of this project lies in the fact that the participating HS teachers will continue to teach the aviation curriculum in their respective classes, with frequent updates from the university faculty.

BACKGROUND

Introduction of aviation-related curriculum in high schools has shown not only rise in interest among the students to learn more about the aviation industry but also the possibility of sustainably implementing the curriculum utilizing existing equipment [8]. In addition, exposing the students to aviation-themed learning activities has shown to help with determining the motivation and self-efficacy levels of the students toward STEM-based curriculum [9]. In addition, since UAS technologies are uniquely positioned to help with variety of workforce needs, exposing students to UAS curriculum has shown to better prepare students towards STEM careers [10].

Utilization of simulators has been noted to be one of the methods of enhancing learning experiences for the students and overall safety during training [11]. As it has also been shown that students' efficacy may also increase after the students are engaged in a technology-enhanced learning environment such as computer-based [12]. Through experiential learning where students engage with tangible materials and experiences, they are able to construct knowledge and better understand the concepts [13], [14]. As Tep et al., noted, a significant difference in students' comprehension was observed after the students were exposed to aviation-themed learning activities [15].

In evaluating the performance of the students, pre- and post-assessment tools have been shown to help with understanding the students' prior knowledge mastery and their eventual learning growth after the training [16].

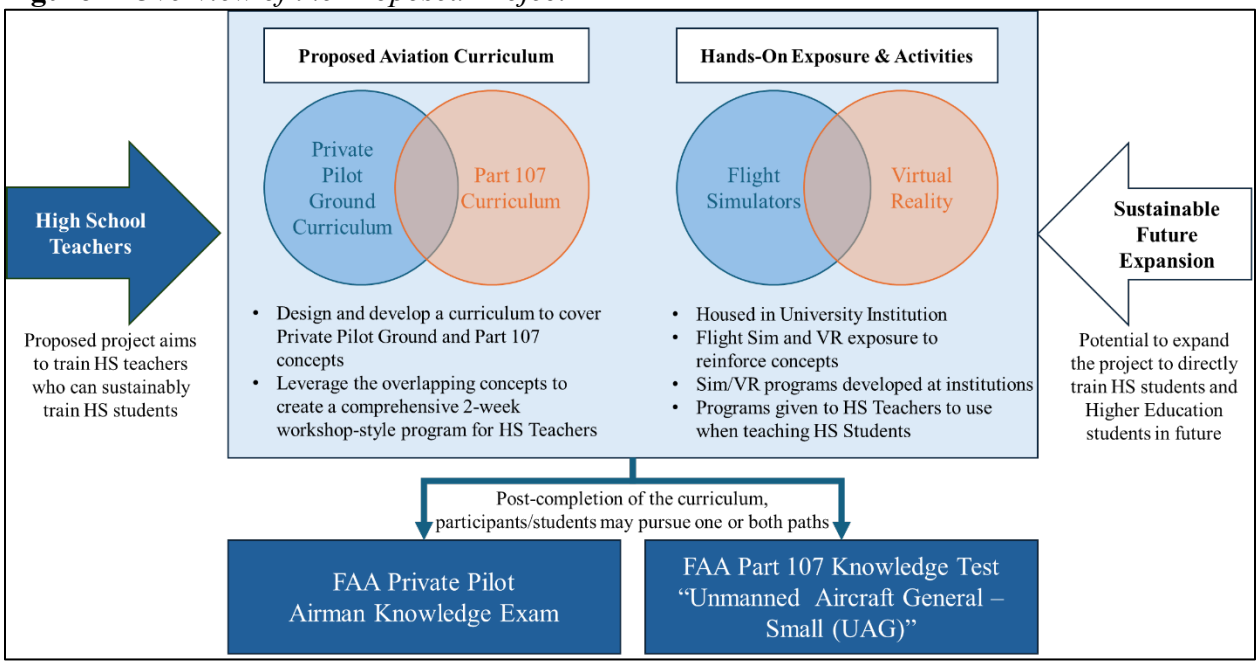
PROPOSED FRAMEWORK AND APPROACH

The proposed framework focuses on equipping high school teachers with the tools and training needed to deliver a sustainable aviation curriculum to high school students, and contribute to the aviation workforce development need. The framework aims to develop an aviation curriculum that integrates concepts from both the FAA Private Pilot Ground School and Part 107 UAS curriculum, creating a unified two-week workshop supported by hands-on exposure to flight simulators and virtual reality (VR) systems. These immersive experiences, developed and hosted at institutions, will be designed to reinforce technical content, and prepare teachers for effective classroom instruction. Upon completion of the developed curriculum, high school students can pursue one or both certification pathways: the FAA Private Pilot Airman Knowledge Exam or the FAA Part 107 Unmanned Aircraft General (UAG) test. Figure 1 provides an overview of the proposed framework: development of the aviation curriculum, integration of hands-on activities, training and equipping of HS teachers, a future expansion potential, and the potential FAA certification outcomes.

The primary goals of the proposed framework include:

a) **Goal #1:** Create an aviation curriculum incorporating *immersive, hands-on learning activities* to provide high school (HS) students with meaningful and engaging aviation education to prepare future aircraft pilots and/or Unmanned Aerial System (UAS) operators.
b) **Goal #2:** Initiate and conduct *robust outreach* regarding careers in commercial aviation as a professional aircraft pilot or unmanned system operator, including outreach to populations that are underrepresented in the aviation industry.

Figure 1. *Overview of the Proposed Project*



Objectives and Approach

The proposed self-sustaining and affordable curriculum is designed to be implemented at high schools with an overall idea of preparing students to become aircraft and/or UAS operators. To effectively achieve the primary goals of the framework, the project is subdivided into three major objectives consisting of multiple operational tasks. This section briefly explains the three objectives and an overview of the sub-tasks within each objective. The operational sub-tasks may be developed based on the specific application settings. As such, the major objectives to pursue in the implementation of the proposed framework include:

1) ***Objective #1*** *– Design and develop an engaging aviation curriculum comprised of FAA Private Pilot Airman Knowledge and FAA Part 107 Knowledge, which prepares high school students for the FAA Private Pilot Airman Knowledge exam and/or the FAA Part 107 Unmanned Aircraft General – Small (UAG) knowledge test to become UAS operators.*

   This objective focuses on developing an engaging curriculum and includes three major steps. First, a mapping of FAA Private Pilot Airman Knowledge and FAA Part 107 Knowledge is needed to identify overlapping topics, specific topics, and opportunities for a holistic aviation curriculum. Next, specific topics and concepts must be identified where incorporating a variety of hands-on learning activities and assessments through flight simulators and/or Virtual Reality (VR) programs would benefit students in acquiring, understanding, and retaining relevant information. Then, specific hands-on learning activities with the use of flight simulators and/or VR programs must be designed and developed to help reinforce student learning experiences. This holistic and immersive curriculum, along with hands-on activities, will aim to help HS students explore UAS career opportunities in fields like logistics, construction, and agriculture.

2) ***Objective #2*** *– Employ a sustainable curriculum delivery approach to educate HS teachers on the developed aviation curriculum and equip them with training, support, and supplies to effectively deliver the curriculum to HS students.*

   This objective focuses on building a sustainable approach to deliver the developed immersive aviation curriculum by organizing and preparing a 2-week intensive workshop to educate HS teachers and provide them with the hands-on educational tools. First, a select group of twenty (20) HS teachers (number may depend on the application setting) will be thoroughly recruited. Recruitment criteria for HS teachers may include teachers who already teach relevant courses, show commitment to attend workshops, and demonstrate dedication to teach aviation curriculum to HS students. The developed framework may have support resources such as adequate scholarships for the teachers to complete the immersive workshop, become Part 107 certified, and receive training on effectively delivering the curriculum content in their respective high schools. Similarly, recruitment criteria for HS students may include interest to go through the curriculum and being in 9^{th} to 12^{th} grades. HS teachers and students from public, private, rural, and urban HS are encouraged to participate.

   Next, a detailed 2-week workshop will be conducted to equip the HS teachers with the developed curriculum, training, support, and supplies to educate/prepare HS students to become private pilots and/or UAS operators. Participating HS teachers will utilize state-of-the-art aviation facilities (flight simulators, and VR UAS simulators) as part of the hands-on learning experience. The workshops may cover

the Part 107 instruction and certification preparation for HS teachers. Upon completing the workshop, each participating HS teacher may be provided with three low-risk classroom drones and a set of VR accessories to use in their classrooms to demonstrate the aviation concepts to their respective students. Finally, as an overarching element of the entire framework, the participating HS teachers will be provided with continual curriculum monitoring and support while they implement the aviation curriculum in high schools.

3) ***Objective #3 –*** *Conduct outreach initiatives to increase student awareness and interest in various career pathways as aircraft pilots and/or UAS operators as well as expose HS students to the various applications of UAS through hands-on activities.*

   This objective focuses on conducting inter-institutional visits and targeted invited talks (also in the form of monthly webinars) at regional high schools by framework organizing university team, aviation undergraduate students, or local aviation professionals. These visits will aim to ignite HS students' interest and create awareness of opportunities in the aviation industry. Some outreach activated may include inviting participating HS teachers and their students to the Aviation Education Fair days at the organizing university for an immersive experience with advanced flight simulators on campus. During these visits, HS students may interact with faculty from various disciplines and learn numerous UAS application areas. Students will also learn about various career pathways as aircraft pilots. Activities may also include monitoring and evaluating the effectiveness of the hands-on activities performed by the HS students. HS teachers and students may use these outreach activities to ask questions regarding the progress of the aviation curriculum implementation.

Framework Performance Monitoring and Evaluation

To ensure the effective execution and sustainability of the proposed aviation education initiative, a structured and iterative monitoring and evaluation process must be implemented. The project team may periodically interview participating HS teachers and students, review curriculum collected data, and interview participating HS administrators. These activities will help refocus and realign project efforts if any key objectives or tasks fall short of expectations. The team, in collaboration with the participating HS teachers, can also use survey data, interviews, observations, and other data sources to assess the performance of the students undertaking the aviation curriculum. Periodic status reports may be used to ensure the timeliness of the project.

In addition, it is advisable that the project evaluation is tightly integrated with the ongoing data collection efforts of the project team. The project teams members must seek independent responses to the measurement variables (examples shown in Table 1) to collect and analyze quantitative and qualitative data. The analyzed data must be reviewed for accuracy prior to being incorporated in status reports to ensure precision and timely reporting of the results. To that effect, the project team may collect pre- and post-survey data (and observation data) from the HS teachers participating in the training workshop and establish long-term follow-up connections with teachers and administrators. The team may also survey the teachers annually to document any practice changes, the number of students mentored, and collect curriculum implementation data on HS students' performance as needed. These measures may be indicative of the project impact, as well as the short- and long-term goals of the framework.

Table 1. Suggested Tools and Metrics for Program Monitoring and Evaluation

Processes	Measurement Variables	Data Collection Tool
Professional Development of HS Teachers	HS Teacher satisfaction with workshops	▪ Focus group interviews ▪ Written questionnaire on teacher satisfaction and perceived learning
	Quality of the immersive curriculum and implementation plans	▪ Evaluation of the quality of the teachers' curriculum by project team members
	HS teacher content knowledge before and after workshop	▪ Pre- and post-content assessments ▪ Reflective logs and teacher journals
	HS teachers' interest level and attitudes toward teaching aviation curriculum	▪ Attitude survey provided to the HS teachers before and after they are exposed to the workshop ▪ HS teachers' reflections on their own learning during the process
	Effectiveness of immersive hands-on activities using simulators and VR	▪ Pre- and post-topic-specific assessments
Aviation Curriculum Implementation in Schools	Level of aviation curriculum content knowledge of the students	▪ Pre- and post-tests on aviation topics
	Level of student interest and attitudes toward becoming private pilots and/or UAS operators	▪ Pre- and post-attitude surveys
	Changes in the learning environment of the schools by the aviation curriculum	▪ Interviews with school teachers, administrators, and supervisors
	Impact of indoor classroom drones and VR sets in student learning	▪ Pre- and post-survey for content and attitude assessment
Outreach Initiatives	HS teachers satisfaction level with the outreach events	▪ Post-event written questionnaire on satisfaction and perceived learning
	Student reflections and attitudes toward becoming pilots and/or UAS operators	▪ Reflective reports by participating students
	Impact of aviation fairs and demonstration of larger application-specific drones and flight simulators	▪ Pre- and post-survey for attitude assessment

PROJECT FRAMEWORK IMPACT

The proposed framework offers a scalable and transferable model for institutions to collaborate with their nearby high school administrators and teachers to implement the developed immersive aviation curriculum in high schools. Institutions may adopt this framework, leverage existing educator networks of K-12 teachers involved in other projects with the institution, recruit more HS teachers and students, and embed an immersive aviation curriculum into existing relevant coursework with minimal disruption. The ultimate goal of this framework is to increase student

exposure to aviation pathways, especially aircraft piloting and/or UAS operations, prepare them for respective FAA certifications, and support long-term aviation workforce development.

To ensure meaningful and measurable impact, the project identifies several short- and long-term performance goals. These goals serve as guiding benchmarks for recruitment, training, implementation, and student outcomes. Table 2 outlines these key goals and their corresponding evaluation measures.

Table 2. Proposed Framework: short- and long-term goals and suggested assessment

Performance Goal(s)	Key Measure(s)
Recruitment of HS Teachers	▪ Number of HS teachers who express interest and willingness to participate in training and teach the aviation curriculum
Professional development of HS Teachers	▪ Number of HS teachers who achieve FAA Part 107 certification and demonstrate readiness to deliver curriculum Understanding of curriculum content measured through evaluations
Recruitment of HS Students	▪ Number of HS students impacted through outreach and who show interest in the aviation curriculum
Training and Educating of HS Students	▪ HS student performance in both formative and summative evaluations incorporated in the UAS curriculum ▪ Number of HS students who complete the UAS curriculum and are prepared to take the Part 107 certification test

These performance goals support the primary project goals and outcomes defined through the three major objectives of the framework. Table 3 below summarizes these objectives, their intended benefits, and the expected measurable impacts as institutions implement the immersive aviation curriculum, train HS teachers (who in turn teach HS students), and conduct outreach activities to continually support the aviation education and workforce development at high school level.

Table 3. Proposed Framework: Benefits, Outcomes, and Impact

Objectives	Benefits/Impacts	Measurable Outcomes
Objective #1: Designing and Developing an Engaging Aviation Curriculum Objective #2: Delivering a Sustainable Curriculum to High Schools Objective #3: Outreach Activities	Improved awareness and interest levels among HS students in aircraft pilot and UAS operator careers Continual engagement with HS students through outreach initiatives The need for aircraft pilots and UAS operators in both the region and nation is met A sustainable curriculum delivery approach to help HS students pursue aviation education A process for training HS teachers to integrate aviation related curriculum with their own region or state teaching requirements is realized	A finalized aviation curriculum with immersive, hands-on learning activities tailored to HS Students 20 Part 107 certified HS teachers ready to teach the aviation curriculum in their classes About 400 HS Students are prepared to sit for the FAA Private Pilot Airman Knowledge and/or FAA Part 107 Knowledge exam

CONCLUSION

This paper outlined/proposed a structured and scalable framework focused on establishing an educational program to help faculty in creating and delivering a sustainable aviation curriculum to be taught to high school students. Specifically, the proposed framework is designed to deliver a meaningful aviation education to high school teachers, who in turn will teach high school students. The ultimate goal of delivering such a curriculum is to attract and train high school students to become aircraft pilots and/or UAS operators. With an intensive immersive educational workshop, curriculum design, hands-on instructional tools, and strong outreach activities, the proposed educational framework aims to provide meaningful aviation education to numerous high school students for multiple years. The educational framework contributes to a pipeline for future aviation workforce development in aircraft piloting and UAS operations.

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