aero educate: free aviation-based stem activities for k-12

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Background and Overview

"The aviation industry is a vital sector of the U.S. economy, yet participation in aviation as a career, for business, as an extracurricular activity, as a sport, and as recreation has declined over the last decade. There are many causes for the decline, including a reduced interest in aviation among younger populations and other demographics and a lack of industry promotion" (National Academies of Sciences, Engineering, and Medicine, 2019, p. 6).

Compounding this decline in aviation participation is the imminent retirement of 46.3% of current airline transport pilots in the next 15 years due to the mandatory retirement age of 65 (Regional Airline Association, 2022). Aviation enthusiasts, professionals, and educators need to work together to increase interest in aviation as a career pathway or recreational passion (NASEM, 2019). Multiple researchers, such as Garcia and Manaia (2019), suggest that early exposure to aeronautics is critical. Childhood experiences frame our ways of thinking, methods of processing information, and to a certain degree, our preferences. Children are shaped and/or limited by information and exposure (Bonus, 2021). The need for intentional pathways that promote interest in aviation must start with the very young (NASEM, 2019).

Educators understand the importance of providing a structure that immerses students in authentic learning experiences, provides context for learning, and introduces learners to caring adults as mentors and advisors. Such pathways provide a process to engage students to pursue careers or interests in fields of study like aviation. Establishing and maintaining aviation pathways requires high quality resources and programming. A first step forward is the development, delivery, and easy access to educational activities aimed at students in K–12, college, and beyond (NASEM, 2019). In efforts to meet this need and provide broader exposure to aeronautics discovery and application, AeroEducate was launched by the Experimental Aeronautics Association (EAA).

The AeroEducate initiative builds and delivers a cohesive set of experiences for learners that enable and encourage exploration of aviation and aeronautics for both formal and informal audiences. In any given year, 80 percent of a child's time is spent outside of a formal education environment (Stevens, Bransford, and Stevens, 2018, as cited in Nelson, Beecher, and Heid, 2019). Allen and Peterman (2019) identify that "Informal learning may lead to high levels of domain-specific expertise among those who are motivated to continue their learning" (p.19). Informal education has been a proven vehicle for sustaining interest and supporting the pursuit of STEM education and careers (Habig, Gupta, Levine, & Adams, 2020).

K-12 STEM Educators can easily implement one or more of the AeroEducate activities in their classroom teaching or after-school clubs. Each AeroEducate activity is strategically aligned with multiple standards for successful integration into formal educational settings.

AeroEducate aeronautical activities inspire, engage, and sustain learners' interest in aviation, regardless of the educational setting. These experiences help learners begin a journey that may lead to their discovery of a love for aviation and potential career choice. Through private industry funding and partnerships with institutes

and institutions of higher education, aeronautics-themed and contextualized experiential opportunities are provided for learners. AeroEducate broadens all learners' access to the world of aviation. Through these experiences, learners explore pathways that may ultimately lead to expanded career opportunities within the field.

Aeronautics-themed Activity Development

A team of developers consisting of university faculty, institute personnel, and K-12 educators were selected to design and create the aeronautics-themed activities. The first task for the team was to conduct a thorough review of existing EAA materials, user interface, and access. Based upon this review, strategic areas of aeronautics content and skills were identified. Additionally, the team addressed the need for a central design process and, based upon this process, developed an activity format based upon learner level positioning.

Aligned with best practice, a student-centered constructivist design was followed for the activity structure. This provides a logically sequenced and easy-to-follow format for both formal and informal educators. This consistent organization provides detailed descriptions of activities, resource sets, and methods/approaches for framing engaging activities. The standardized activity format and structure is outlined in Table 1.

Facilitator Support	Learner Focus
Title of Activity	Scenario and Task
Key Concept and Essential Question	Learner Actions
Objective	Independent Practice
Standards Alignment	
Time	
Materials	
Technology Enrichment	
Background Information	
Facilitator Actions	
Guided Practice	

Table 1. *Activity Brief*

Activity Brief Components - *Key concepts and Essential Questions* characterize the grade-appropriate activity for learners. For example, science concepts explored within Grade 6-8 activities include: lift, the Magnus Effect, stability and aerodynamics, the four forces of flight, buoyancy, friction, unbalanced forces, Newton's Second Law of Motion, and sound. Essential questions such as "What happens when a spinning object moves through air?" and "How do you stabilize a plane in flight?" help build context for real-world learning. Where appropriate, already developed EAA learning materials and STEM career videos are incorporated into newly developed activities.

Learning for both formal and informal settings is framed by the *Objectives* specifying the anticipated goal of the activity and identifying what the learner will be able to do and know as a result of the experience. *Standards Alignment* refers specifically to the learner-level designated benchmarks within *Next Generation Science Standards, Common Core Standards in Mathematics,* and *Standards for Technological and Engineering Literacy*. Aligning with standards situates the activity within the context of a trajectory of learning that is age-appropriate.

Time assists the facilitator in planning events and activities. The time ranges throughout the specific activity range from 30-60 minutes for younger ages to 60-180 minutes for older learners. *Materials* provides a list of equipment, supplies, and consumables required for the activity. The *Technology Enrichment* section provides related technology-focused experiences and resources and *Background Information* is included to help facilitators to build context for the learning experience. Novice or veteran aviation facilitators may use the background information to engage learners, enabling them to interact and fully contribute to aeronautics-themed activities. *Facilitator Actions* and *Guided Practice* describe ways facilitators may scaffold the learners' independent practice.

Learner-Focused Components - Guidance for learners is adapted for each grade band, increasing in complexity and autonomy for the older learners. Learner directions and templates are provided, as needed, to support the learning experience. All activities are framed by real-world *Scenarios and Tasks* to build context for learning and introduce career pathways. Setting the stage with a challenge develops a sense of excitement and anticipation for learners. *Learner Actions* describe what learners will know and do during and, as a result of, the activity experience. *Independent Practice* builds individual and/or group autonomy and provides for learner-differentiated facilitation.

In addition to attention to structural components and content, activities are created with developmental learner progression in mind. The activities are designed to address logical learner development grade bands: K-2, 3-5, 6-8, and 9-12. This four-point grade band clustering is used in national benchmark standards to guide the development of age-appropriate content, proficiencies, and readiness. Targeting these grade bands and being informed by standards ensures that the activity and structure variations within newly-developed activities are learner-focused. The intent, design, and structure of the aeronautics-themed activity development strategically fulfills areas of focus within existent EAA outreach materials, aligns with STEM education standards sets, and can be implemented in both informal and formal settings. While the activities are designed as stand-alone activities, the concepts may be combined to create a robust aeronautics learning unit. Titles and concepts of activities are listed in Table 2.

Resource Access

Maintaining a resource repository that is freely accessible is an ongoing objective of the AeroEducate initiative. Full access to the activity and supporting resources is provided once free registration to the AeroEducate website (www.aeroeducate.org) is completed. Resources are organized by grade band and easily accessible through a learning management system. The library of materials includes: activity guides, facilitator guides, student guides with templates,

posters, national standard alignment charts, and developmentally appropriate glossaries. Examples are provided in Figures 1, 2, and 3.

Classroom Implementation

The AeroEducate activities require basic materials and supplies for full implementation within informal settings. Technology and engineering (T&E) educators can easily use the activities as designed, or may supplement and extend the experiences through more in-depth STEM lessons, classroom tools, and equipment. For example, the 9-12 Gliders activity guides learners to cut and construct gliders from balsa wood using a utility knife. Students in T&E courses could modify this experience by designing wing and stabilizer shapes in CAD and exporting their files to be cut on a laser cutter (See Figure 4). As students test their gliders, they observe the fragile nature of balsa wood. Technology and engineering educators may use this real problem to segway into the 9-12 Composite Wing activity, extending and pairing the two glider experiences so students can reinforce their delicate glider wings.

While all activities (K-12) could be used as team-building experience, the 9-12 activities could also be the basis of collaborative engineering experiences for transitional bridge programs from high school to college. The secondary activities are also excellent capstone engineering projects. Figures 5 and 6 depict the 9-12 Lighter-than-Air activity that challenges learners to design a control system for a helium balloon airship and then use lift and differential thrust to steer the airship through an obstacle course. Each activity encourages learner-centered open-ended inquiry and design.

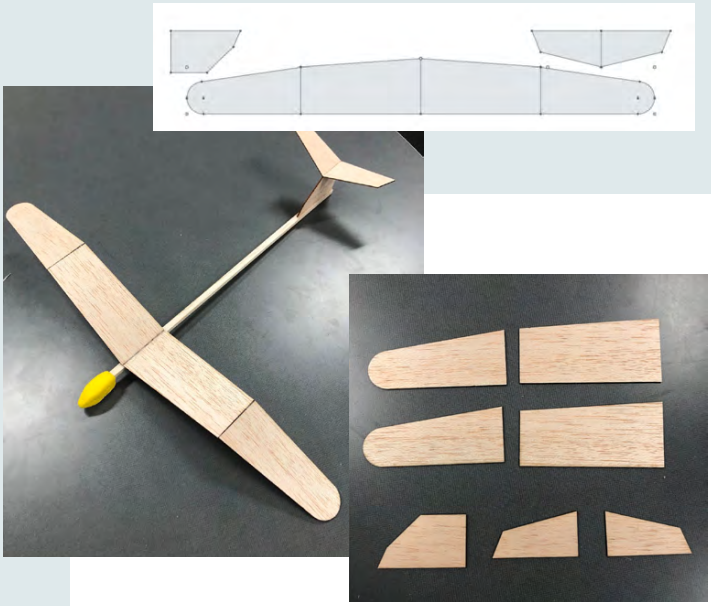

Figure 4. *A balsa glider's CAD drawing, laser cut wings and stabilizers, and the assembled glider from 9-12 Glider activity.*

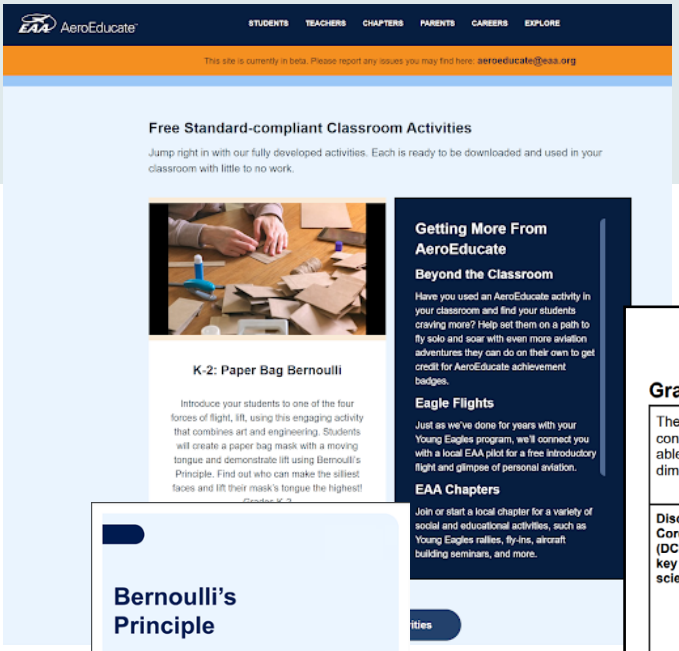

Figure 1. *AeroEducate Activity Access Page*

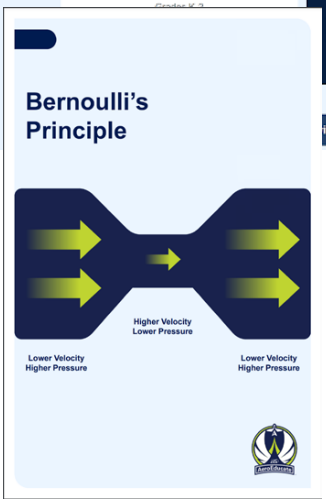

Figure 2. *Supplemental Poster*

National Standards

Grades 9-12

The **Next Generation Science Standards (NGSS)** are K-12 science content standards. NGSS describe what students should know and be able to do. There are three distinct and equally important strands, or dimensions, within NGSS.		Activities					
		1 Flight Stability	2 Airfoil Design	3 Gliders	4 Propeller Design	5 Lighter-Than-Air	6 Composite Wings
Disciplinary Core Ideas (DCI) are the key ideas in science.	PS2A: Forces and Motion	X	X	X	X	X	
	PS2B: Types of Interactions	X	X	X	X	X	
	PS1A. Structure and Properties of Matter						X
	PS1B: Chemical Reactions						X
	PS3A: Definitions of Energy					X	
	ETS1A. Defining and Delimiting Engineering Problems	X	X	X	X	X	X
	ETS1.B: Developing Possible Solution	X	X	X	X	X	X
	ETS1.C: Optimizing the Design Solution	X	X	X	X	X	X
Science and Engineering Practices (SEP) describe what scientists do to investigate the natural world	SEP 1: Asking Questions and Defining Problems	X	X	X	X	X	X
	SEP 2: Developing and Using Models	X	X	X	X	X	X
	SEP 3: Planning and Carrying Out Investigations	X	X	X	X	X	X

Figure 3. *National Standards Alignment*

K-2 Talon	3-5 Aviore	6-8 AeroPioneer	9-12 AeroExpedition
Guided Inquiry Facilitator Driven	←	→	Open Inquiry Learner Driven
Air Traffic *Flight Plans and Communication*	**Blended Wing Body** *Four Forces of Flight*	**Magnus Cups** *Magnus effect* *Lift*	**Airfoil Design** *Aerodynamics* *Lift* *Bernoulli's Principle*
Corn Syrup Races *Drag*	**Bubbling Rocket Launch** *Drag* *Newton's Third Law*	**Straw Plane** *Stability*	**Composite Wings** *Composite materials*
Drag Races *Drag*	**Land Sailing** *Forces and Interactions*	**Hot Air Balloons** *Four Forces of Flight* *Buoyancy*	**Flight Stability** *Balance* *Flight Stability*
Paper Bag Bernoulli *Bernoulli's Principle*	**Nose Cones** *Drag*	**Hovercraft** *Unbalanced Forces* *Friction*	**Gliders** *Aerodynamics* *Forces of Flight*
Paper Bag Kites *Lift*	**Tumblewing Gliders** *Lift* *Bernoulli's Principle*	**Quiet the Skies** *Sound*	**Lighter-Than-Air** *Forces of Flight*
Whirlygigs *Rotors* *Rate of Descent*	**Two-Loop X-Planes** *Four Forces of Flight*	**Balloon Plane** *Forces* *Interactions*	**Propeller Design** *Thrust*

Table 2. *Activities in each grade band. Activity name is in boldface, scientific concepts in italics.*

Figure 5. *A design in the Lighter-Than-Air 9-12 activity.*

Figure 6. *A student measures lift.*

Summary

Although designed for informal educational structures and non-formal providers, the AeroEducate initiative offers youth in a variety of settings an initial exposure to the world of aviation and aeronautics. Real-world and context-based experiences spark learners' interests and may help them discover a personal and/or professional passion for the field. Through AeroEducate, EAA provides quality resources for facilitators to build awareness and increase exposure and opportunities for youth. The collaboration between EAA, NC State, and the National Institute of Aerospace demonstrates how higher education and industry partners can and should work together to address STEM workforce needs.

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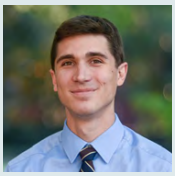

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