Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
1988 Volume VI: An Introduction to Aerodynamics

Mankind's Fascination With Flight

Curriculum Unit 88.06.01
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1.1 *Introduction/Rationale*

Why do airplanes fly? How in fact can anything that is heavier than air fly? For the record and for the life of me I did not really know why. At least I didn't know prior to this curriculum unit. Oh, I'm familiar with the basic terms such as lift, drag, wing, power, etc. But, I really had very little scientific understanding of the science and fluid mechanics behind it all. I must admit I'm in awe of flying. It does appear to be almost magical in its power and poetry. My unit will be something of a document of my own education regarding the science and the history of flight. I am not a scientist and have come to teach science only recently. I, like my students, come to many of these scientific problems with limitations and gaps in my formal scientific education, armed more with curiosity and desire to learn than anything else. Therefore, my unit will not be an exhaustive and intensely mathematical analysis of flight, filled with equations and uniquely scientific terms. Hopefully, my unit will be a guide for my students for a discovery of the magic and marvel of flight, emphasizing understanding, motivation, and participation.

This unit will revolve around a collection of miniunits discussing the science of flight and some of the men who contributed to the historical progression of flight, both technically and inspirationally.

Many students that I have worked with over the years these scientific courses, books, and lectures we have designed for them too difficult, too abstract, or too boring. Obviously we need to begin to present the ideas of science in more enjoyable and fresh ways. I hope my unit will succeed on that level. As I have stated previously, I do not want my students to be bogged down with heavy technicalities, though the real world of work will make its own demands. What I do want is to transmit the wonder of flight to them so that it may spark their own investigations into all that science and the potentials of mankind have to offer.

The aforementioned mini-units will be based on several of the major accomplishments of mankind detailing the evolution of flight. I would like to spend some time developing each mini-unit so that it would cover three areas. First each of these mini-units will concern itself with the philosophy and the imagination behind the specific accomplishment. Another way of looking at this would simply be to ask the question, "Why did man want to fly or attempt to fly in this particular fashion?" Secondly, each mini-unit will discuss some mechanics involved in the specific event. Lastly, each mini-unit will attempt to discuss and gain some insight into the implications of the specific historical event for future progress. Simply stated, "How did one step lead to the next?" Tying this all together will be a discussion and examination of the science of flight. Each mini-unit will be an examination, loosely organized in the following manner:

1.2 *The Quest*

The Quest will deal with man's early, initial attempts in studying the flight of birds, and attempting through drawings, sketches, and crude models to design methods of flight. This will also concern itself with balloon flight.

1.3 *The Mastery of Flight*

The Mastery of Flight will examine man's early attempts at flying, and success as embodied in the investigations and eventual accomplishments of Orville and Wilbur Wright.

1.4 *Extending The Mastery of Flight*

This section will briefly discuss the accomplishments of Charles Lindberg. His success will serve to illustrate the two great, necessary ingredients of any push forward regarding science, technical skill and the human spirit.

1.5 *Extending The Mastery of Flight: The Sound Barrier*

This section will examine the new age of flight as mankind breaks the sound barrier.

1.6 *Extending The Mastery of Flight: Human Powered Flight*

Here we will discuss the recent developments of flight using new materials and human power.

1.7 *Teaching Outline*

My unit will be taught over a four-month period using three to four class periods per week. This unit will represent about 1/3 of my science curriculum for the school year. This unit will be most appropriate for students in grades fifth to seventh but might be modified for students in other grades. According to many educators and educational psychologists (Piaget) children must go through a series of stages of growth refining their ability to process information. A lot of what happens intellectually must by nature of these stages unfold over the course of many years (1). Yet, this process can also be "hurried" or nurtured through a stimulating, experience-filled environment (2). We as teachers need to move ourselves (and students along with us) from a less concrete stage to a more operational stage where science becomes a way of understanding abstract concepts and increased information processing instead of rote memorization of facts.

1.8 *Unit Objectives*

The main objective of this unit will be to discuss, examine and appreciate the science and inspiration of flight. Other goals and objectives of this unit are the following: To use flight as a means to teach basic science; To use the "magic" and the inspiration of those involved in the evolution of flight as a catalyst to spark the imagination of my students in the appreciation of science; To familiarize my students with the terms and mechanics of powered flight; To improve my students' achievement in scientific concepts, reading comprehension, vocabulary skills, and critical thinking skills.

1.9 *Strategies*

The unit will attempt to teach about flight using an eclectic approach. I will, throughout the course of this unit, use lectures, slide presentations, film strips, videos, teacher directed reading sessions, brainstorming/critical thinking skill sessions, as well as some practical (and fun) hands on experiences.

Introduction to Aerodynamics

Aerodynamics is the branch of dynamics that deals with the motion of air and other gaseous fluids, and with the forces acting on bodies in motion relative to such fluids. For the purposes of this unit and in hopes of maintaining simplicity and clarity, aerodynamics will focus itself on air as it relates to the wings and body of an airplane, or more simply, on what makes airplanes fly.

2.1 *Flight*

Because airplanes are heavier than air, they have to rely on their engines to give them power and their wings to provide lift, an upward force that overcomes the plane's weight. Without them both, airplanes would not be able to stay in the air. Four forces affect the flying of an airplane: lift, weight, thrust, and drag. Flight depends upon these forces being balanced. If lift is greater than weight, the plane climbs higher and higher. If thrust is greater than drag, the plane's forward speed will continue to increase. The process of powered flight requires the application of forces to accomplish it. In order to sustain an object at a given elevation above the surface of the earth, a constant lifting force must be provided to counteract the effect of gravity (3). Something must supply this lifting force.

In the case of the fixed-wing aircraft, the basic idea is to get the aircraft into the air by creating forward motion to supply lift. Since this forward motion is running the plane into the air, the lift can be provided by a fixed structure (4). Essentially the forward propulsion has nothing to do with lift, but is necessary to get the wings moving against the air at a rate sufficient to provide moving against the air at a rate sufficient to provide lift.

In the design of an airplane for forward flight, total drag must be kept to a minimum if the power requirements are to be kept reasonably low (5). Any drag, whatever the reason, will require the use of power to overcome it. The process of streamlining is designed to reduce drag to a point as low as possible.

In forward flight the lift is provided by the reaction of the wings upon the air as the plane is driven forward to engage it. Both lift and drag are to be viewed in terms of dynamic pressures caused by air flowing against the aircraft(6).

As a general rule it is considered that about 3/4 of the total lift is generated by the action of the upper surface of the airfoil. The efficiency of an airfoil can be described as a ratio of lift to drag (7).

2.2 *Lift*

Wings have a special shape called an airfoil. This shape gives strength, a smooth airflow, and better lift. The top half of the wing is curved more than its underside, and thus air flowing over it moves faster than air beneath it. As a result, the air exerts less pressure on the wing's upper surface and higher pressure below produces an upward lift. It had been proposed many years ago that a "vortex acting on the wing is the cause of lift" (7). This vortex or circular air motion has since been studied extensively in the field of fluid dynamics.

Professor Peter P. Wegener in his article, “The Science of Flight”, in the Journal, *American Scientist* , explains this phenomenon thusly, “We begin with a circulatory flow with concentric streamlines around a rotating cylinder. To this flow is added a second flow from left to right. A flow pattern is created with asymmetrical streamlines above and below the cylinder. The flow speed above is higher than that below’‘(8). These effects upon the cylinder are in reality what happens to the airfoil; pressure above is lower, pressure below is greater and lift is created. This is known as the Magnus effect(9). A wing or airfoil is forced by a streamlined contour. The line that is equidistant between upper and lower surfaces is the “mean camber line”. The “chord” or “chord line” of the section is determined by joining the two end points of the mean camber line by a straight line. The “angle of attack” of the section is the angle between the undisturbed freestream direction of the flow and the direction of the chord line(10). The amount of lift is determined by the angle of attack, the angle at which the airfoil is inclined to the air. Because of this definition, cambered wings can be expected to provide lift at zero angle of attack(11).

2.3 *Weight*

The takeoff weight of an airplane varies by type. It is the plane itself, the passengers, cargo, and the fuel. New materials (plastics and “mixed” metals) save weight and fuel. Planes taking off from areas with high, thin altitudes and hot air temperatures must carry less weight(l2).

2.4 *Drag*

Planes are smooth-surfaced and are shaped to reduce drag (the resistance of the air to the plane flying through it). The shape of both the wings and the body or fuselage affects drag, and the most efficient planes are those with the best ratio of lift to drag(l3). Today computers are used to find the best possible shapes. Reduced drag means less fuel is required.

(figure available in print form)

2.5 *Thrust*

The plane is moved forward through the air by thrust. In a jet plane, air escaping from the exhausts propels it forward. A larger or heavier plane requires more powerful engines. So does a plane with poor drag or lift.

2.6 *Control of The Plane*

A plane with only a fuselage, wings, and engines would be very unstable(l4). A tailplane, which is a small “wing”, and a vertical tail fin provide stability. Adjustable surfaces on both wings and tail control the direction of flight.

(figure available in print form)

2.7 *Pitching*

If the nose of the plane is displaced upwards by air currents, the tail will move down(15). The pilot makes a correction by pushing the control column forward. The elevators are moved downward, increasing the upward force on the tail. This lowers the nose and returns the plane to level flight, preventing the to-and-fro rocking called “pitch”. If the elevators remain lowered, the plane will descend.

(figure available in print form)

2.8 *Yawing*

If the plane is yawing, the nose goes one way first, then the other way(16). The vertical tail fin helps prevent this and keeps the plane flying straight. A moveable rudder on the tail gives directional control. Turning the rudder to the left increases the force on that side and pushes the plane's nose left.

(figure available in print form)

2.9 *Rolling*

The plane will roll if the wing tips are displaced up or down(17). It will also slide sideways toward the lower wing unless corrected by the rudder. Wings are designed to slope upward from the body of the plane to improve stability, but the ailerons at the ends of the wings on their rear (tailing) edge give pilots control. To bank and turn the plane to the left, the left aileron is raised. The right aileron is lowered, increasing the lift on the right wing. Then the left wing tilts downward and the plane turns.

(figure available in print form)

2.10 *Flying The Plane*

Once cleared for takeoff a plane turns into the wind which assists in providing lift for takeoff. You need a certain air speed for takeoff, this is the speed on the runway for still air, or the differential speed with respect to wind. As the speed for takeoff is increased the pilot pulls back the control column, to raise the nose. As the plane's angle to the ground increases, so does its lift which is more powerful than the plane's weight(18). On landing the plane, the pilot flies to a point in line with the runway threshold, the throttles are closed and forward speed is reduced. Lift is maintained by lifting the nose, thereby keeping lift equal to the weight of the plane and assisted by the use of flaps. Speed continues to fall as the plane is lined up for landing until the plane touches down, transferring its weight from air to ground.

2.11 *Flaps and Spoilers*

The elevators, rudder, and ailerons give the pilot control over the plane's direction. Flaps and spoilers are designed to help with lift on takeoff and landing. The flaps are moveable extensions of the wing; they increase the wing area to provide extra lift when it is needed. Spoilers mounted on top of the wing assist the ailerons. When a spoiler is raised, the increased drag means that the plane descends. In normal flight the flaps are retracted into the wing and the spoilers are kept lowered.

(figure available in print form)

*Looking down on section of wing. #3,4,7, and 8 are the flaps.

%5 and 6 are spoilers.

(figure available in print form)

3.1 Propellers

Propellers are not flat but are curved, like aerofoils. They behave in the same way, with the blades striking the air at a low angle of attack and developing thrust in the way a wing develops lift(19). Advance design propellers can change their angle of attack to produce the maximum degree of thrust. Variable pitch propellers can be set fine for full power and low speeds (takeoff) or coarse for high forward speeds with reduced engine revolutions (20).

Propellers are common on small light piston-engine planes. When driven by a jet engine they become a turbo prop, developing much more thrust at takeoff.

3.2 *Jet Engines*

In the jet engine, air is drawn into the intake and compressed, with a resulting rise in pressure. Fuel is added and burned in a combustion chamber. This produces a high-speed hot gas. It flows through a turbine, which uses just enough of the energy from the gas to power the compressor, while the rest of the energy provides thrust, as it escapes at speed through the exhaust nozzle.

(figure available in print form)

History of Flight

There have been many individuals, who have through an advancement of some technical skill or through the sheer inspiration of their personality, progressed the science of flight. Actually, too many to include in this discussion. Therefore, only a few representative individuals and their achievements will be noted. Each is a representative of their own particular time, and each evokes the spirit and essence of the “magic” of flight.

4.1 *The Quest*

As far back as 1480’s, Leonardo da Vinci had a curiosity and eye for life and its complexity. Flying was one of his strongest interests. Though never to fly himself nor to create a workable flying machine, da Vinci sensed the science behind flight. He writes, “A bird is an instrument working according to mathematical law, which instrument it is within the capacity of man to reproduce with all its movements but not with a corresponding degree of strength, though it is deficient only in the power of maintaining equilibrium (21). Leonardo da Vinci obviously felt that man could reproduce the mechanics of flight by imitating the birds. That he was wrong, and in fact constructed models that could never fly misses the point. His inquisitive mind and probing spirit acted as a catalyst for others after him. That these who followed da Vinci refined and in many cases discarded his ideas on flight only serves to illustrate that invention is very often an evolutionary process. We build as much on inspiration as we do on technically correct formulas. Probably the first aerial voyage of any kind that man attempted successfully was in a balloon. In 1783 two gentlemen, Messrs. Rozier and Marquis d’ Arlandes, using the technology supplied by two brothers, Joseph and Etienne Montgolfier, set sail in a balloon for a brief trip across Paris. The technology behind this balloon trip was simple; heat causes expansion and consequently reduces the weight of air. This balloon was in reality a “floating chimney”, powered by burning straw(22). Though this flight lasted only 25 minutes over a distance of about five miles it did serve as a springboard for the imagination, and as a focus for the competitive, inventive spirit.

In 1785 Jean-Pierre Blanchard and Dr. John Jeffries crossed the English Channel for the first time by air using an improved balloon design.

Balloon designs (lighter than air) reached their peak in the form of the dirigibles. These were used for exhibition and warfare. More importantly, regular transatlantic traffic had been carried out for years. Had it not been for the horrible tragedy of the Hindenburg in 1937, both dirigibles and zeppelins may have enjoyed a greater success, even into our own time.

In 1896, the Langley Aerodrome Model No. 5 had demonstrated the possibility of mechanical flight. Designed by Professor Samuel Pierpont Langley, this model was powered by a small steam engine. This unmanned model made the first significant flight of any engine driven heavier-than air craft(23). It flew twice on the afternoon of May 6, 1896, launched from a houseboat on the Potomac River. Professor Langley’s later attempts at manned flight in a full-sized version of the Aerodrome were unsuccessful. Also launched from a houseboat anchored in the Potomac, the larger craft hit the water almost immediately after launch in October 1903. A second attempt in early December ended in similar fashion.

As a parallel to these powered attempts at manned flights, there was considerable energy being spent in flying using gliders. The most successful of these was the glider constructed by Otto Lilienthal in 1894(24).

Basically, gliders had a pilot hang between the wings by bars that passed beneath his arms. Lilienthal made glides of up to 1,150 feet in machines of this type. Despite his faith in the safety of his invention, Lilienthal was killed following a crash in one of his hang gliders.

Apparently, Lilienthal's death was not in vain. It is reported that the aviation pioneers, Orville and Wilbur Wright had read about and were much impressed with Lilienthal's experiments(25). These attempts at flight by Lilienthal had obviously acted as a strong incentive to the brothers Wright, to try their own flights with engine powered heavier-than air flights. Another great influence upon the Wrights was OctaVe Chanute. Chanute, a successful engineer, was himself very interested in gliders and powered flight. His knowledge of previous aerodynamic experiments and his encouragement acted as a strong motivator to Orville and Wilbur.

4.2 *Mastery of Flight*

Apparently, though mankind had dreamed of powered flight, and had worked hard at it for many years, interest in this being accomplished was slowly but surely fading. All previous attempts had ended in failure. As it is with many experiments that appear solvable but continually end in failure over many years and many attempts, the invention of the airplane by the Wright brothers was from a design almost uniquely their own. The Wright brothers using the inspiration of Lilienthal, together with his awareness of the curved wing as superior to the flat wing, perfected the correct curvature of the wing, thereby removing an impediment to successful powered flight that had previously been little understood(26).

After much experimentation and reading, after much discussion and application of the laws of aerodynamics, as they themselves had investigated and solved, the Wright Brothers were on the doorstep of an event that would change the course of the world forever.

On December 17, 1903, the Wright Brothers successfully flew the first powered heavier than air craft. Their plane was an innovative combination of lightness and strength(27). The plane flew a distance of 120 feet on the first trial and their last flight covered 852 feet and lasted 59 seconds.

There is some apparent misunderstanding regarding the Wright brothers. There is the idea that the success was accomplished by two expert mechanics making an isolated test of a flying machine they just happened to be working on, something done in their spare time(28).

The Wrights had worked almost continuously for over five years, solving problems, difficult and minor, theoretical and technical. They labored over problems as diverse and complicated as wing warping control, integrated wing warp and rudder control, construction of their own aircraft engines and propellers, and of course their experiments in aerodynamics(29). As stated previously, the Wrights alone were able to test and understand the profound significance of an accurate airfoil.

4.3 *Extending The Mastery of Flight*

On May 20-21, 1927, twenty-five year old Charles Lindbergh made the first solo, nonstop transatlantic flight in his specially constructed plane, the Spirit of St. Louis." The flight took 33 1/2 hours. Lindbergh took off from Roosevelt Field, Long Island on the morning of May 20, 1927 and 33 1/2 hours later landed at Le Bourget Field near Paris, France to a hero's welcome. One hundred thousand people were there to greet him.

His plane was constructed in such a fashion, that Lindbergh to see forward, had to either turn the plane or use a periscope; a gas tank was installed where the windshield normally would have been.

Lindbergh, not even counting the significant technical feats involved in his aircraft, epitomized the true and adventurous spirit of the men who took the next step in advancing the art and skill of flying. Lindbergh's feat was accomplished a mere 24 years after the first successful flight of the Wright Brothers.

4.4 *Extending The Mastery of Flight: The Sound Barrier*

On October 14, 1947, a little more than 20 years after Lindbergh's historic crossing of the Atlantic Ocean another milestone was reached in aviation history. Captain Charles "Chuck" Yeager, U.S. Air Force, flying his rocket powered craft, the Bell X-1, became the first person to fly faster than the speed of sound in a sustained, level flight. Remember, the speed of sound is 670 miles per hour! Only 44 years before, Orville and Wilbur Wright had managed to soar for the first time ever at a more modest speed of 35 miles per hour. Amazing!

4.5 *Extending The Mastery of Flight: Human Power*

In the summer of 1977, the seemingly impossible became possible. Though man did not exactly fly like the birds, he came close. In a craft flown over a "considerable" distance, powered by nothing more than his own stamina attached to bicycle pedals turning a propeller, mankind entered the age of human powered flight. This craft, the "Gossamer Condor" designed by Dr. Paul MacCready and Dr. Peter Lissamen, and piloted by Bryan Allen covered a closed course for seven minutes while skimming just a few feet above the surface of the ground. Though the craft is small and fragile, it is decidedly "hi-tech", using the latest (for that time) in composite materials, computer assisted design, and a small array of enthusiastic engineers, scientists, and support people. The sheer technical marvel of this flying machine coupled with the ingenuity and persistence of the people who designed, built, and flew it is not a brilliant but isolated feat, but a clear and natural progression of all who labored and dreamed about the marvel of flying before it.

This "first" of human-powered flight has itself been "outdone", extended by the development of newer materials, designs, and ideas as embodied in the craft named the "Daedalus". The "Daedalus" a human-powered craft like the Gossamer Condor" was successfully flown over a distance of 74 miles, skimming just a few feet above the Sea of Crete.

As we move into the 21st century, we can be justifiably

optimistic about our ability to solve present and unforeseen problems. Our inspiration can come from many reminders and testaments to the brilliance of the human mind and spirit, not the least of which is man's fascination with and mastery of flight.

5.1 *Vocabulary: Activities For Students*

Have students look up definitions of these words. Use the words in sentences.
Aerodynamics Yawing

Fluids	Pitching
Flight	Rolling
Force	Ascend
Elevation	Rudder

Counteract	Flap
Gravity	Ailerons
Streamlining	Throttle
Pressure	Propulsion
Airfoil	Mach
Lift	Vortex
Drag	Weight
Thrust	Efficiency
Ratio	Angle
Reaction	Altitude
Exhaust	Fuselage
Descend	

6.1 *Questions/Descriptions*

Why is the top half of a wing curved more than its underside?
List the four forces that affect the flying of a plane. Briefly describe each.
What do the terms pitching, yawing, and rolling mean as they relate to the flying of an airplane?
What is meant by the “Angle of Attack”?
What is meant by the “Magnus Effect”?
When taking off from a runway, why does the pilot raise the nose of the aircraft?
Why are propellers curved?
What did the Wright Brothers understand and “perfect” that previous inventors failed to accomplish?
Why do hot air balloons fly? Explain.
Why was Lilienthal of such importance to the Wright Brothers?
What is meant by the ratio of lift to drag?

7.1 *Lesson Plan: Heating Air*

Introduction The heating of air makes it expand, thereby making it lighter and rise.

Objective Students will be able to demonstrate that the heating of air makes it lighter and therefore rise.

Materials Balloon, electric light bulb, heating source.

Procedure Stretch a rubber balloon over the neck of a column which has been made from a used electric light bulb. Heat the column/container slowly with a small flame and observe how the balloon begins to fill up and expand.

7.2 *Lesson Plan: Field Trip*

Introduction Make arrangements for your class to take a field trip to the local airport. Have one of the officials explain and demonstrate the various parts of an airplane, taking special note to observe wings and propulsion systems. Plan for a question and answer session with your class and the pilot.

Objective Students will be able to discuss and describe the various parts of an airplane.

7.3 *Lesson Plan: Research Paper*

Introduction Students need practice in locating information, reading the information, comprehending the information and then writing about what they have read. Have students research: aerodynamics,balloon flight, Wright Brothers, Human Powered Flight.

Objective Students will be able to locate, read, discuss, and prepare a short research paper on subjects dealing with aerodynamics and flight.

7.4 *Lesson Plan: Bernoulli's Principle*

Introduction Using Daniel Bernoulli's principle of higher speed of a flowing liquid or gas, creating lower pressure, explain, demonstrate the concept of lift.

Objective Students will conduct a simple experiment demonstrating the principle of lift.

Materials A dime; A small plate.

Procedures Place the dime about 1/2 inch from the edge of a table top. Position the plate a few inches from the coin on the tabletop. Blow a quick, strong blast of air across the top of the coin. The dime will leap into the air and with practice will land on the plate.
The blowing air across the top of the coin creates an area of low pressure. The atmospheric pressure in the room rushes in to fill the area of low pressure. This force provides the lift causing the coin to leap up and land on the plate.

7.5 *Lesson Plan: Wright Brothers Model*

Introduction In order for students to gain an appreciation for the accomplishments of the Wright

Brothers while studying about them in a lecture format, the students together with the teacher can build a scale model of their powered airplane from a commercially available kit.

Objective Students will be able to observe and manipulate structures similar in reference to the plane constructed by the Wright Brothers. Students will gain an appreciation for the skill and work involved in building, direction following, team work and application of academic skills.

Procedure The Wright Flyer Kit No. 202 is available by mail order, may be purchased at various hobby shops and at the National Air and Space Museum in Washington, D.C. This model when constructed (plywood) will have a wingspan of 58 inches. The model is close to 1/8 scale and can be flown as a free flight glider or as a kite.

Materials Wright Flyer Kit No. 202, Scissors, X-ACTO knife, Model Glue, Elmer's Glue

7.6 *Lesson Plan: Powered/Glider Model*

Introduction As a closing project, one which will be both enjoyable and important in terms of pulling together all of the previously learned and discussed material, the class will build a combination electric powered and glider airplane from a kit. This kit called the "Electra" will require about one month of construction time.

Objective Students will be able to observe, discuss and build an actual flying, powered (electric) aircraft from a model kit.

Procedure Classroom will purchase the "Electra Sailplane" from a local hobby shop. The "Electra" measures: wingspan 78", length 41", and weight 48 ounces plus motor. The plane is hand launched and has two mile range which includes loops, stalls, and glides. The "Electra" is radio controlled.

Materials
"Electra Sailplane Kit"

Various small tools.

8.1 *Activity Field Trip*

Class or various members of the class together with teacher will visit the National Air and Space Museum in Washington D.C. Exhibits include Wright Brothers Plane and Lindberg's "Spirit of St. Louis".

8.2 *Slides*

Slides taken at the National Air and Space Museum in Washington D.C. of the various aircraft under discussion will be used throughout the unit to highlight the various accomplishments under discussion. Students will be encouraged to make their own slides.

8.3 *Book Reports*

Students will read the biographies of any of the pioneers of aviation, Wrights, Lindberg, etc. and prepare a book report detailing the individual's accomplishments.

Notes

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21 Neville Duke and Edward Lanchbery. 1961. *The Saga* of Flight. The John Day Co. New York.

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26. Orville Wright. 1953. *How We Invented The Airplane* . David McKay Co. Inc. New York.
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