Science Through Science Fiction in a Hot Air Balloon

Nancy Baulis
CatharineElementarySchool

Overview
Rationale
Objectives
Strategies
Classroom Activities
Annotated Bibliography/Resources
Appendices

Overview

Students can have a feeling that Science is very difficult to learn. They like doing experiments or activities in class, but the real factual information challenges them. The Philadelphia Zoo has a hot air balloon that my students have seen if not actually taken a ride up in the sky. They are excited by the thought of hot air balloon rides. By showing the connection, between the popular old movie *Wizard of Oz*, based on a book, that is fantasy with parts that would fall under science fiction, the unit will show how Science and Science Fiction are intertwined. The hot air balloon shown at the end of the movie will act as a beginning to study not only hot air balloons, but also weather and aeronautics. Dirigibles, such as the *Hindenburg* will be included in the unit. The students will be fourth and fifth graders. The unit will be multidisciplinary combining math, writing, reading, and social studies along with science. The unit is designed for 6 weeks with a 45 minutes lesson a week.

Rationale

My school is located in Southwest Philadelphia, and is a predominately African American student body from families of lower incomes. Our students need extra help with reading and math. However, Science is an important subject that can include the same skills needed for learning reading and math. The students know that learning science can be enjoyable and I wish to expand on that feeling.

Human beings have tried to fly since the beginning of recorded time with attaching wings to the arms and going over cliffs. However, earliest successful flight came from balloons.

Hot Air Balloons

The first documented flight was on August 8, 1709 by Bartolomeu Lourenco de Gusmao a young Brazilian priest. The flight occurred in the palace of King John V of Portugal. The balloon was constructed of paper over a wood frame, above a brazier burning some materials that caused it to fill with hot smoke. Rising quickly, it was prevented from reaching the ceiling, as with other attempts fire escaping was a concern. (Hallion 32-33)

In 1783, two brothers who were papermakers Joseph and Etienne Montgolfier, and another Frenchman, a scientist, Jacques Alexandre Cesar Charles, finally achieved designs to carry a human into flight. (Hallion 47) The idea came to Joseph, while he should have been studying law in 1782, how to carry soldiers over and into fortresses. Like fire and ash being carried up a flue, couldn't the heat be contained and used to operate a conveyance. Joseph, using a piece of taffeta covering a wood frame, let it become smoke filled and then released it and watched the balloon float to the ceiling. (Hallion 48) Etienne Montgolfier launched a balloon made from varnished taffeta. The occupants on this flight of the *Martial* were a sheep, a duck and a rooster. The demonstration was for Louis XVI and Marie Antoinette, on September 19, 1783 at Versailles, and was a success. (Hallion 52) The brother's Montgolfier were the first to design and launch a man in a balloon, Jean Francois Pilatre de Rozier on October 15, 1783, the *Montgolfiere* was azure with gold trim. An actual flight over a section of Paris occurred on November 21, 1783 the men were de Rozier and Francois Laurent, the Marquis d'Arlandes. The balloon was more rounded in design, which used paper backing under linen envelope instead of taffeta, which leaked. The new *Montgolfiere* was also very decorative with royal blue and gold depicting the signs of the Zodiac, a bright sun, the fleur-de-lis, and the king's initials. (Hallion 53)

J. A. C. Charles who used cold gas, hydrogen, headed the other design team. Hydrogen had been discovered 17 years earlier. Charles was a scientist and a friend of the American Minister to France, Benjamin Franklin. The *Globe* was spherical in shape and made of taffeta backed by rubberized latex. The Charles team also decided to launch their balloon in Paris on August 27, 1783 and had two Americans in the audience, Benjamin Franklin and future president John Quincy Adams, who was a teenager. (Hallion 49 to 51) Charles and a member of his team Noel Robert made another flight on December 1, 1783. The *Charliere* had a covering similar to fishnet as a layer to reinforce, as well as, to hold the lines to the ground. The balloon traveled 25 miles and after a safe landing was found to be undamaged. Charles then flew alone and discovered the pain in the ear caused by a sudden change in pressure. (Hallion 55 to 57) Other pioneers continued to experiment with balloon flight. On June 4, 1784 the first female, Elisabeth Thible flew over Lyons in a Montgolfiere, *la Gustave.* (Hallion 58)

Various governments were interested in early balloons to be used for battle, the first seen with the French Revolution of 1789. The balloons were to be powered by hydrogen, and constructed in sections glued together and covered with varnish. The balloons were used for surveillance and dropped messages to give troop information. The French established an aeronautical training facility at Meudon the first in history. (Hallion 63) But, it did not last, France closed its balloon school in1802 and aerostatics would not be used for another 50 years. There were a few attempts to have bombs on unmanned flights, because the wind caused problems, such as in 1849, when the Austrians tried to use balloons to bomb Venice. (Hallion 66) Balloons were used for entertainment in France, even though they were not being used for battles.

In the United States, balloons had been used for pleasure trips. Americans had seen 3,000 flights carry over 8,000 riders into the air, by 1859. The balloon was used in the American Civil War. President Abraham Lincoln witnessed a demonstration in June 1861 by Thaddeus S. C. Lowe sending a message to the White House by telegraph 1,000 feet above. The first “aircraft carriers” actually were for balloons. Another balloonist John La Mountain drew Confederate sites while floating 2,000 feet above Sewell’s Point on August 3, 1861. Lowe continued to help the Union forces and the military supported balloon usage, such as General Ambrose Burnside and General George McClellan. The Confederate army was not able to establish it’s own balloon force. (Hallion 66 to 69)

Ballooning being used for entertainment was continuing in Paris by Gaspard Felix Tournachon known as Nadar. He was a photographer who liked publicity and was a close friend of Jules Verne. Nadar was the first in 1863 to use a balloon as means to advertise his balloon rides and aerial photographs. (Freeman 23) Nadar also developed stereoscopic aerial photography to map sections of Paris. On a flight in 1867, Nadar had a double-decker basket that carried 12 people over the Champ de Mars. Because of Nadar ballooning as a military tool was revised.

During the Franco-Prussian War of 1870-71 while Paris was under siege. Nadar convinced French general Louis Trochu to fly posts over Prussian lines. The flight occurred on September 23 and 11 hours later after floating over the Prussians landed at the Chateau de Cracouville over 60 miles away. The French minister of the interior, Leon Gambetta escaped Paris on October 7. He became the first government official, from any country to fly in a balloon. Balloons transported 102 passengers, 11 tons of dispatches and 1.5 million letters from the City of Lights. The balloons also made history by carrying communications that could be classified as “microdot”. A photographer Rene Dagron was able to store 2,000 characters on film about an inch by 2inches, using a microscopic photographic reproduction process.

From 1794-1897, 17 nations had started balloon services to assist their armies throughout Europe, the Americas and Asia. America used a balloon over Cuba in 1890 to help with the capture of San Juan Hill. (Hallion 70 to 73)

Scientific experiments were also conducted using balloons. Helium powered balloons were considered the best because of greater lifting power over the heat induced lift. However, in London on November 30, 1784, a balloon powered by heat took Aeronaut Jean Pierre Blanchard and physician John Jeffries to a height of 9,000 feet to measure temperature, humidity and air pressure. Jacques Garnerin took flight over Paris with a parachute attached to the gondola, on October 22, 1797. Garnerin came down to an altitude of 2,300, cut the lines of the gondola and using the first parachute landed back on the ground. The condition known as anoxia (deprivation of oxygen to the brain) was experienced in1803 by a French physicist, Etienne-Gaspard Robertson, when he reached a height of 24,000 feet. Other experiments that tried to gain even higher altitudes could not always be proved, as the scientists passed out, as with a flight in England in1862. But there were recorded heights of 24,000 again, but with the use of oxygen delivered through sucking on the tubes attached to bags of oxygen, in 1874. (Hallion 74 to 77) From 1845 to 1897 many expeditions set out to find a Northwest passage to connect Europe, America and Asia by water and to land on the North Pole. A Swedish scientist, Salomon August Andree, headed one of the most famous expeditions. Andree became interested in ballooning after meeting the aeronaut John Wise at the United States Centennial in1876. Andree starting 1893 to take trios in his balloon the Svea to gain experience for an Artic trip. The balloon that carried Andree and two other scientists was called the Eagle and lifted off on July 11, 1897. Unfortunately the trip proved to be a disaster, when the balloon became too cold to continue to fly. The explorers would continue on foot, but could not withstand the artic conditions. The last diary entry was written on October 17 and it would be thirty years later that the bodies and equipment of the exhibition were found. (Norgaard 100 to 111) The exhibition had come within almost 500 miles of the North Pole. One important fact that was discovered at this time was that oxygen must be used continuously during the flight, if higher altitudes are going to be attempted. (Hallion 79-80) By 1909 the balloon makers were turning to making aircrafts instead of airships to continue the progress of flight. (Hallion 237)

As the years went by, ballooning became a sport and a form of entertainment for many people. In 1908 a balloon week in Berlin had eighty balloons from Germany, England, France, Belgium, Spain, Switzerland, Italy and the United States participating in a flight duration competition. A Swiss balloon was in the air for forty-three hours and thus won. An American ship burst at 3,200 feet, but the team was found on the roof of an apartment building. (Norgaard 115) A fad that developed was that of jumping from a balloon, but as the wind could take the jumper farther away, it was also dangerous, so did not last. (Norgaard 152)

Achieving higher altitudes was a continuing area of experimentation. A Swiss professor Auguste Piccard, designed an elongated balloon with an aluminum car enclosed at the bottom. Piccard was able to reach an altitude of over 51,000 feet on May 27, 1931. His next flight into the stratosphere was in August and reached 54,000 feet. A Soviet team reached 59,000 in 1933. When the Russians tried to improve their record in 1934, the car broke away from the balloon at almost 69,000 feet. Unfortunately, the car crashed and all on board died. An American team in 1934 had problems at 59,000 feet when a tear developed in the balloon covering. The team also discovered that a line from the car to the balloon had torn loose. The team was able to parachute to safety when the balloon blew apart at 20,000 feet. In 1935 the American team of Captain Orvil Anderson and

Captain Albert Stevens were able to reach an altitude of 72,000 feet. (Norgaard 162 to 165)
During World War II the kite balloon was also used as a captive balloon, when enemy planes were caught in the nets below the balloons. Over 2,000 captive balloons helped protect England from German bombs dropped from airplanes. (Norgaard 181-182)

An old-fashioned balloon was used in an attempt to cross the Atlantic on December 12, 1958. The four aeronauts were from England a father and son Arnold Eiloart and Tim Eiloart and Colin and Rosemary Mudie. The balloon flew for almost ninety-six hours, when it was caught by a strong updraft. The Small World was coming from the Canary Islands traveling to the West Indies. Fortunately, the balloon car had been fitted as a boat and when the balloon came down after four days, the boat sailed on for twenty days arriving in the West Indies on January 5, 1959. (Norgaard 184)

Today’s hot air balloons with an onboard heat source can be traced back to one developed by Ed Yost starting in the 1950s. He was able to take flight on October 22, 1960. Vijaypat Singhania in India set the altitude world record on November 26, 2005 at 69,849 feet. Oxygen is needed for all on board when the altitude exceeds 12,500 feet. The record for the longest flight was made on January 15, 1991 on the Virgin Pacific Flyer with Per Lindstrand and Richard Branson. The team flew from Japan to Northern Canada 4,767.10 miles. The volume was 2.6 million cubic feet the largest balloon envelope ever built for a hot air craft. The balloon was made to fly in the trans-oceanic jet streams and hit a record ground speed of 245mph. The longest time in the air was set on January 2, 1997 at 50 hours and 38 minutes made by Michio Kanda and Hirosuke Tekezawa in Japan. (en.wikipedia.org/wiki/Hot_air_balloon 4)

If a flight occurs today, the hot air balloon would have a bag known as the envelope that has the ability to contain heated air. Attached at the bottom would be a gondola or wicker basket that carries the passengers and the source of heat. This heated air has a lower density than the somewhat cold air outside the envelope, thus making it buoyant. In a gas filled balloon the bottom would need to be sealed. The fabric of sport balloons is usually made from ripstop nylon or dacron (a polyester) and the mouth near the burner flame is made from Nomex a fire resistant material. (en.wikipedia.org/wiki/Hot_air_balloon 1) The burner sends a flame into the envelope to heat the air inside the envelope. The fuel is propane, a liquefied gas kept in tanks. (en.wikipedia.org/wiki/Hot_air_balloon 4)

To construct an envelope, the fabric is cut into sections and stitched together, with load tapes (webbing) that can handle the weight of the gondola or basket. These sections fall from the crown (top) to the mouth (throat) and are named gores or gore sections. The envelope may have anywhere from 4 to 24 or more gores. Another feature of an envelope is a crown ring that is a hoop of 1foot in diameter and made of aluminum that has the vertical load tapes attached. The balloon can be coated with a sealer usually silicone or polyurethane to seal against air. The envelope can be small for one person and does not

have a basket these are called “Hoppers” or “Cloudhoppers”. The volume would be less than 1,000 meters cubed and a radius of about 44 feet. The large balloons that can carry over twenty-five people have volumes of over 15,000 meters cubed. Usual balloons are 2,500 meters cubed and carry three to four people.
(en.wikipedia.org/wiki/Hot_air_balloon 4-5)

Vents in the top of the balloon can be opened to increase the descent and are called parachute vents. Slower descents for landing are started by letting the air in the balloon cool naturally. The shape can be different and for competitions designs try to decrease the aerodynamic drag for better performance. (en.wikipedia.org/wiki/Hot_air_balloon 5-6)

The baskets are usually made of woven wicker or rattan with a rectangular or triangular shape. Holes found woven into the basket are used for foot holds to climb in or out. Aluminum baskets that can be folded have lighter weight and are used when records are being made in altitude, duration or distance. (en.wikipedia.org/wiki/Hot_air_balloon 6)

A gasoline engine fan will start blowing up the balloon. The burner is lighted when the pilot uses a flint striker, lighter or built-in piezo electric spark. As the burner gasifies liquid propane, mixes it with air, ignites the mixture the flame and exhaust are directed into the mouth of the envelope. The process is all started when the pilot opens the blast valve. A whisper burner may be used when flying over livestock, so not to cause them to be spooked. The whisper burner has a more yellow flame and it lights up the inside of the envelope better, so is used at night. (en.wikipedia.org/wiki/Hot_air_balloon 6-7)

A fuel gauge and pressure gauge will be attached to the propane tanks with a valve at one end to feed the burner and the tank will be made of aluminum, stainless steel or titanium. A pilot will also have instruments to guide as the flight is occurring usually an altimeter, a rate of climb indicator, thermometers for envelope air (inside) temperature and ambient air (outside) temperature. (en.wikipedia.org/wiki/Hot_air_balloon 7)

In order for lift to occur, the warmer air inside the balloon must be of a higher temperature then that of the ambient (outside) air. The force is similar to floating in water. Usually the air inside the balloon is a maximum 120 degrees C (250 degrees F). The exact amount of volume and temperature needed for lift depends on ambient temperature, altitude above sea level and humidity of air in the area. Calm and cool air with winds fewer than 10 miles per hour are the best conditions for a balloon launch.
(en.wikipedia.org/wiki/Hot_air_balloon 8)

Safety is a concern that is addressed by having two systems on board the balloon, in case one system/burner/fuel tank fails, so a landing can be achieved. Pilots wear flame resistant gloves and where the burner hangs from the balloon and not attached to the basket, helmets are also worn. The ground crew also wears cloves to prevent robe burns when bringing the balloon to a stop. All parts of the balloon; envelope, basket, burner must be kept clean, dry and in good repair for safe flying. (en.wikipedia.org/wiki/Hot_air_balloon 9-10)

All balloons in the United States that carry passengers must be registered and have an N-number and airworthiness certificate and pass inspections. Pilots must also have a certificate from the Federal Aviation Administration (FAA) (en.wikipedia.org/wiki/Hot_air_balloon 11)

Dirigible

There were ideas to put rudders or use propulsion to enable the balloon to be steered. However, the design needed to be changed to be more elliptical in shape and the balloons would look like early blimps. These blimps were also plain to look at and not decorated with colorful designs. The steam engine helped to continue the progress toward a streamlined airship. Henri Gifford, a French steam engine designer built a blimp like airship 144 feet long. Gifford's ship was powered by a three horsepower steam engine and had a three-bladed propeller and had a coke-burning boiler and the exhaust was in a downward stream. Gifford became the first to fly a steer able airship on September 24, 1852. Wind was a problem as with all balloon designs. (Hallion 81 to 83)

Aerodynamic designs were developed, so the dirigible would aide in the progress of air flight. In 1884 a ship called la France with an 8.5-horsepowered electric motor designed by Captain Arthur Krebs and driven by a lightweight battery array designed by Captain Charles Renard was the first completely controlled powered flight of any sort. Krebs and Renard were able to take off and return to the same spot and land their flying machine. Krebs and Renard continued to experiment and carried passengers on flights including the first woman to fly in an airship, an actress named Gaby Morley. (Hallion 87)

It was in 1863, when a young Ferdinand Graf von Zeppelin, visiting the United States and on leave from the army of the king of Wurttemberg took a balloon flight to study the Union Army. His desire to learn more technology and to develop a rigid airship waited until his time in the military ended. Von Zeppelin's idea was a rigid airship that had lift via gas and aerodynamic lift acquired from its shape and "wings". The development of the internal combustion engine aided in his future success in building a dirigible. The LZ1 for Luftschiff Zeppelin-1 was launched on July 2,1900. The dirigible had taken two years to build and had no government backing. The LZ1 was 420 feet in length, a diameter of over 38 feet and powered by two Daimler 14-horsepowered engines. The construction consisted of aluminum-zinc alloy with 24-sided polygon frames and braced by wire. The shape was likened to a long cigar. There were 17 gas cells of hydrogen gas. The five passengers including von Zeppelin were fortunate to survive with various problems during the 18 minutes of flight, but it was able to safely land. (Hallion 94 to 98) Von Zeppelin continued to experiment with his blimp and in 1909 he established the first airline of its kind in history DELAG (for Deutsche Luftschiffahrt Aktien Gesellschaft, the German Airship Travel Corporation). (Hallion 268)

During World War I German dirigibles were used in battle to drop bombs, but they were usually attacked and set on fire by airplanes and could not maneuver as well as an airplane. Another problem happened at the higher altitudes when water in the ballast tanks and cooling water in the engines froze. (Norgaard 142 to 147) Another type of balloon/dirigible was developed called the kite balloon, which was used for artillery observation. (Norgaard 181)

The term blimp comes from the sound the airship makes when one taps the envelope with a finger. Lt. A. D. Conningham of the British Royal Navy is believed to have coined the term in 1915. In 1925 Goodyear Tire & Rubber Company began building airships of the blimp design. (travel.howstuffworks.com/blimp1.htm)

The airships were also to be used to try to explore the North Pole region. The airship the Norge, piloted by Colonel Umberto Nobile landed at Nome after a trip of 3,400 miles in 1926. Nobile was so inspired by that trip in the Norge, that he was able to get another ship the Italia for another expedition. Mussolini thought this trip could bring his fascist government prestige and was there in Milan for the lift off on April 15, 1928. As had happened in the artic expeditions in balloons, dirigibles also had problems with wind and ice. The Italia did cross the North Pole on May 24, but then problems started. A control car on the bottom of the Italia crashed and caused the men to be thrown, but nine out of the ten survived. The airship with six men in the other control car lifted of and was never seen again. Now the expedition was grounded, but was able to start to send a radio signal. They were not started to be rescued until June 20 some were airlifted in a two-seater plane and others were rescued by ship, but it would take months. (Norgaard 154 to 160)

The *Hindenburg* had its trial run in March 1936. The ship's capacity was more than 6,700,000 cubic feet, weighed almost 200 tons and could reach a speed of almost 85 miles an hour. The Hindenburg had two stories to accommodate fifty passengers with cabins, dining areas, lavatories, lounges, and had a crew of 40. The giant airship made regular transatlantic crossings between the U. S. A. and Germany. The ship made twenty crossings over the North Atlantic. However, on the ships twenty-first crossing in May 1937, fog was encountered and the ship climbed higher to avoid the density of the atmosphere. When the ship was preparing to land in a downpour an explosion was heard. The first explosion was amidship, the second was aft and then more explosions came like cannon fire. It was after the first explosion that the entire ship seemed to be in flames. Some passengers jumped to avoid the flames and tried to crawl away, others lay still on the ground. The crash of the *Hindenburg* killed thirty-six men and women. It is believed that the *Hindenburg* had been hit by lightning. Because of the crash, these giant airships were not to be the transportation for large numbers of passengers. The concern raised afterwards was why was the flammable hydrogen filled in the airship instead of nonflammable helium. Germany had problems procuring helium from the United States (the only country producing it). The German government could have purchased the helium, but did not think it could spare the required foreign exchange. The *Graf Zeppelin* was to be used for passengers, but by September 1938, helium could not be bought from the United States. (Norgaard 176 to 179)

The G-Class and L-Class blimps built by Goodyear during WWII were for training purposes for the military. K-Class and M-Class blimps were built as anti-submarine and operated during WWII. N-Class blimps (the “Nan ship”) built by Goodyear were used for anti-submarine and as a radar early-warning platform during the 1950s. By 1962, the military had stopped using the blimps. Today there is a fleet of Goodyear blimps that operate for advertising and as a television camera platform. (travel.howstuffworks.com/blimp1.htm)

Blimps use gas to generate lift and are called airships and are lighter-than-air crafts. They can move through the air under their own power similar to airplanes. As with helicopters blimps can hover. Unlike a hot air balloon, they can fly no matter what the weather conditions are at the time and stay in the air for days. (travel.howstuffworks.com/blimp.htm 1)

Helium gas is held in the envelope of the blimp and the cigar-shape enhances the aerodynamics of the ship. The lightweight fabric is similar to the material used for space suits. The polyester composites for the material to produce the envelope are made by ILC Dover Corporation that makes spacesuits for NASA. The envelope can hold 67,000 to 250,000 cubic feet of helium for a certain blimp. (travel.howstuffworks.com/blimp1.htm 1-2)

The front of the blimp is kept stiff so as to have an aerodynamic shape and for protection when traveling forward and being moored, this is possible by nose cone battens. The nose of the blimp is the location of the mooring hooks. Similar to the ballast tanks of a submarine a blimp has two ballonets air-filled bags, one fore and one aft. The ballonets are deflated or inflated with air for the blimp to ascend or descend. The air is necessary as air is heavier than helium. These ballonets are also used to keep the blimp trim or level. Suspension cables are attached to catenary curtains sewn into the sides and length of the blimp to attach the gondola. Mounted to the tail are flight control surfaces that consist of the rudder to steer and the elevators to control the angle of ascent or descent. The two engines cause the thrust to move the blimp ahead. These engines are turbo-propeller airplane engines that run on gasoline and are air-cooled. The engines are located on the sides of the gondola and allow the blimp to fly at 30 to 70 miles per hour. Air scoops are able to help the pilot to fill the ballonets while flying by directing the exhaust from the propellers into the ballonets. The pilot to release air in the ballonets to adjust the helium pressure in the envelope uses valves and there is a helium valve as well if the pressure would become unsafe. The gondola, which is enclosed, is where the pilot and passengers ride. The equipment in the gondola also includes communication to be in touch with ground support and navigational compasses, airspeed indicators and in some cases weather radar. Blimp pilots are FAA-certified and a ground crew follows in a van with mechanics. (travel.howstuffworks.com/blimp1.htm 2-3)

Aeronautics
The study of airflow was the most necessary to advance any type of flying machine. Leonardo da Vinci studied aerodynamics for humans to fly. During this time scientists observed and reasoned to explain phenomena rather then testing a hypothesis. We now know that an area of low pressure above a bird's wing compels the wing upward, not as da Vinci thought that the downward thrust of the bird's wing caused the lift. Even Sir Isaac Newton studied flow and resistance. (Hallion 101) Fluid flow was first studied in advance of the study of airflow around airplanes. A Frenchman Henri Pitot devised an L-shaped tube that he connected to a pressure gauge to measure the speed if flow in a fluid. In 1732, he used the instrument to measure the flow of the River Seine and found the speed of a river decreased at lower depths. A modern Pitot tube is still used today as an airspeed-measuring tool on gliders to jets. An Englishman, Benjamin Robins designed a whirling-arm rig to measure air resistance. He was interested in ballistics and cannons. (Hallion 103) Finally Sir George Cayley created aeronautics. He was a person who was totally committed to flight from gliders, to helicopters, airplanes and balloons. Cayley found his interest in aviation in 1792, from a flying helicopter model. In 1796, Cayley replaced twin two-bladed rotors with twin four-bladed rotors he used bird feathers and wine corks to build his model. At the age of 23, he understood that larger rotors on a bigger machine could have a man flying. Ballooning helped to encourage Cayley to carry out his own research of aeronautical study. From the years of 1799 to 1810, Cayley experimented to develop a flying machine. He knew that winged flight had four forces to deal with power to overcome drag so wings could produce lift and overcome gravity. Cayley saw the difference between keeping a plane in the air from the lifting power of its wings and propelling the plane in the air from the power of its engines. (Hallion 105 to 108) All experimenters in flight would examine aerodynamics and then build an aircraft to test the research toward the end of the nineteenth century. (Hallion 108) Cayley saw the benefit of dihedral or angling a wing upwards to gain more lateral and directional stability. He also developed a tail on his aircrafts to act as a rudder and the need for a stable wing that was tested in 1809. (Hallion 109-110)

A marine engineer Francis Herbert Wenham, was a founding member of the Aeronautical Society of Great Britain. Wenham discovered in 1866 the most lift produced by a wing was near the leading edge of the wing. A wing needed to be broad in span. In 1871 Wenham took a large fan and blowing air around a model hanging in a wooden trunk open at both ends, became an aeronautical tool, the wind tunnel. The wind tunnel enabled researchers to test wingspans and lift-to-drag values, as aeronautics advanced. (Hallion 115 to117)

Aeronautics is the science of flight and means, “sailing the air”. Aerodynamics is the physical science that is the interaction of the motion of air with an object in motion. The fluid dynamics and gas dynamics—all gases are part of the study of aerodynamics and the understanding of the motion of air, flow field around an object. The properties of a flow field velocity, pressure, density and temperature as a function of position and time. A control volume around the flow field and the mathematical analysis and wind tunnel experimentation form the scientific basis for heavier-than-air flight. (en.wikipedia.org/wiki/Aeronautics)

Objectives

The students will have a beginning understanding of the intricacies of flight by studying the hot air balloon, dirigibles and concepts of aeronautics. Weather not only played a factor in the early flying machines, but it is watched for today’s flights, so that will be an area of study for the students.

Strategies

Before beginning research the students will brainstorm with the teacher using KWL (what you know, what you want to know, and what you want to learn). Skills of doing research on the Internet and using encyclopedias and other books would be reviewed. Flight is such an interesting topic for students so they will want their questions answered. The students will learn by becoming aeronauts in a research sense, as the lessons continue. We will discuss if the days weather would be good for a flight. Daily weather will be checked on the National Weather from the newspaper.

Classroom Activities

There are three fourth grade classes and four fifth grade classes. Each group would participate in all of the forty-five minute lessons.

Lesson One

Objective: To introduce the unit and have students want to investigate the three main topics; how hot air balloons fly, how dirigibles were different and basics of aeronautics.

Activities: Show a brief clip of the movie The Wizard of Oz, where the wizard and Dorothy try to leave Oz in a hot air balloon. Complete a KWL chart with the students, it should show their understanding of hot air balloons and how they fly. Have pictures of modern hot air balloons and have the students identify some of the parts to introduce the beginning vocabulary:

Aeronaut: is a balloonist
Ambient: air the air around the outside of the balloon
Altimeter: an instrument that tells how high the balloon is
Bag: the fabric bubble of the balloon
Burner: the device that burns the fuel
Chase vehicle: truck that follows and picks up the balloon

Crown: the center of the top of a balloon
Fuel: propane gas similar to kitchen stove gas
Gasoline engine fan: used to start blowing up the balloon
Ground speed: how fast balloon is traveling over the land
Mooring or tethering: tying balloon in place
Morning air: calm and cool air for better flights (Freeman 42-43)
Weather concerns for flying will also be discussed at the end of the lesson.

Lesson Two

Objective: For students to understand that the basic designs have not changed drastically by showing balloons from the beginning of their development and to initiate an understanding of aerodynamics.

Activities: Again using pictures of balloons complete the vocabulary:
Nylon: light, strong fabric to make balloon bags
Pyrometer: a temperature gauge for the bag or envelope
Rate of climb indicator: an instrument that tells pilot how fast he is ascending or descending
Rigging: equipment and ropes, cables that hold the basket to the balloon
Safety line: a heavy cord that can open the flap or valve at the top of the balloon to release the heat
Sparker: used to light the burner
Stair step: stopping at various altitudes to check wind direction
Wind speed: the speed at which the wind travels over the ground (A balloon usually cannot launch in winds over 10 miles per hour.) (Freeman 43-44)
Introduce facts of history and related aeronautical discoveries (pressure build up in ears)

Lesson Three

Objectives To have students appreciate that it is not that easy to control a hot air balloon. Students continue to have an understanding of aeronautics. Weather factors will be continued, as related to flying a hot air balloon.

Activities: The students will construct their own balloons to be flown in the classroom and then in the hall. The students will decide what should be in the basket, considering the weight factor. The balloons will be made from tissue paper sections clued together and inflated with a hair dryer. After the test flight, the balloons will then have ribbon added to have the basket (small jewelry box) attached. The students will repeat with the hair dryer. Height, distance and speed will be calculated for each flight.

Bibliography

Freeman, Tony, *on the move…. Hot Air Balloons*, Chicago, Children's Press, 1983. Pages 23 and 42 to 44

Hallion, Richard P., *TAKING FLIGHT Inventing the Aerial Age from Antiquity through the First World War*, New York, Oxford University Press, 2003. Chapters 2 to 6 and 13, 14.

Norgaard, Eric, *The Book of Balloons* Translated and revised by Eric Hildesheim, New York, Crown Publishers, Inc., 1971. Pages 110 to 111,115, 142 to 147, 152, 154 to 160, 162 to 165, 176 to 179, 181 to 182, 184.

en.wikipedia.org/wiki/Hot_air_balloon pages 1-11

travel.howstuffworks.com/blimp.htm page 1

travel.howstuffworks.com/blimp.htm pages 1 to 3

en.wikipedia.org/wiki/Aeronautics

Annotated Bibliography for Teachers

Chant, Christopher, Illustrations by John Batchelor, *A Century of Triumph The History of Aviation*, New York, The Free Press, 2002. This book does not mention balloons, but does cover dirigibles. It would be a good reference book for anyone wishing to learn about aviation.

Gernstein, Joanne, *Fly Now*, London, 1978. Traces flight from the hot air balloon to the 777 "Worldliner". Illustrations showing scenes from the early balloon and posters advertising balloons with circus acts, as well as showing the balloon as a billboard. Because of the various illustrations, the book should be in the classroom during the unit.

Hallion, Richard P., *TAKING FLIGHT Inventing the Aerial Age from Antiquity through the First World War*, New York, Oxford University Press, 2003. The book does indeed trace the development of flight through the ages. There is a lot of detail and background information for studying the topic of early flight. Various details of the pioneers and scientists lives are also given.

Norgaard, Eric, *The Book of Balloons* Translated and revised by Eric Hildesheim, New York, Crown Publishers, Inc., 1971. As stated on the cover this book has 400 illustrations in color and black and white. I would suggest having available to students during the unit

as a resource. It contains facts found in *TAKING FLIGHT*, but easier to read and concentrating on balloons. There is more scientific information in *TAKING FLIGHT*.

The Poster Collection of the Smithsonian National Air and Space Museum, Washington, D.C., National Geographic, 2007. Facts and pictures of hot air balloons and other flying machines. Another good book to have in the classroom, when teaching the unit.

Annotated Bibliography for Students

Baum, L. Frank, pictures by W. W. Denslow, *Wizard of Oz*, USA, Rand McNally, 1985. The book that the movie was based upon. The introduction by L. Frank Baum from April 1900 is interesting to read. It is on page 178 that the balloon really enters the story near the end. The balloon from Omaha was used to attract people to the circus. Students may wish to read the book.

Freeman, Tony, *on the move…. Hot Air Balloons*, Chicago, Children's Press, 1983. Good history and showing how hot air balloons work and the joy of riding into the air. Vocabulary for the unit taken from this book.

Murphy, Bryan, *Experiment With Air*, Minneapolis, Lerner Publications Company, 1991. A book of activities and experiments. The class will use Make own hot air balloon on pages 18 and 19.

Parker, Steve, *Tabletop Scientist The Science of Air Projects and Experiments with Air and Flight*, Chicago, Heinemann Library, 2005. Various topics such as wind, pressure, flow, control, spin for models and experiments. Students will need an adult for some work to be completed.

Priceman, Marjorie, *Hot Air the (mostly) true story of the first hot-air balloon ride*, New York, Atheneum Books for Young Readers, 2005. This picture book of the duck, sheep and rooster will be enjoyable for older students too. The pictures are colorful and the pictures and facts on the inside back cover will add to the resources for the unit.

Resources

Movies
Wizard of Oz, 1939 The wizard leaves without Dorothy near the end of movie.
Around the World in Eighty Days, 1956 A hot air balloon is used to cross the Pyrenees.
Enduring Love, 2004 A hot air balloon is involved in a tragic accident during the opening scene.

The Balloon Federation of America
P.O. Box 346

Indianola, Iowa 50125

If you Google hot air balloon, there are 2,510,000 web sites, which are mostly locations in the United States that give rides. However, here are some sites that could be used for students and teachers:
www.ushotairballoon.com
www.hotairballooning.com
http://travel.howstuffworks.com/blimp.htm
http://travel.howstuffworks.com/blimp1.htm
http://en.wikipedia.org/wiki/Hot_air_balloon
Hot Air Balloon Simulator http://www.balloonsimulator.com-learn the dynamics of a hot air balloon on the Internet based simulator
Hot Air Balloon Newspaper Video and Picture Europa http://www.balloonsworld.com
www.exploratorium.edu//c/balloons
www.overflite.com
www.lessonplanspage.com/scienceExHotAirBalloonFloatsWhyMO68.htm
imagine.gsfc.nasa.gov/docs/ask_astro/answers/970106.html
www.balloonings.com
The Teacher's Institute at Yale posts 40 web sites connected to Hot Air Balloons:
www.yale.edu/ynhti/curriculum/units/1990/7/90.07.05.x.html
www.yale.edu/ynhti/curriculum/units/1994/5/94.05.06.x.html

Appendices

The Philadelphia standards that align with the Pennsylvania State Standards

Fourth Grade:
3.1.4 Unifying Themes
- A. Know that natural and human-made objects are made up of parts
- B. Know models as useful simplifications of objects or processes.
- E. Recognize change in natural and physical systems.

3.2.4 Inquiry and Design
- A. Identify and use the nature of scientific and technological knowledge.
- B. Describe objects in the world using the five senses.

3.4.4 Physical Science, Chemistry and Physics
- C. Observe and describe different types of force and motion.

Fifth Grade:
3.1.7 Unifying Themes
- A. Explain the parts of a simple system and their relationship to each other.

3.2.7 Inquiry and Design
- B. Apply process knowledge to make and interpret observations.

3.4.7 Physical Science, Chemistry and Physics
- B. Relate energy sources and transfers to heat and temperature.

3.5.7 Earth Science
- C. Describe basic elements of meteorology.